NWRF 09-1165-110



# A METEOROLOGICAL PROBABILITY SYSTEM

# for

# PLANNING CARRIER OPERATIONS

DEPARTMENT OF THE NAVY
NAVY WEATHER RESEARCH FACILITY







U. S. NAVY WEATHER RESEARCH FACILITY
BUILDING R-48, U. S. NAVAL AIR STATION
NORFOLK, VIRGINIA 23511

NOVEMBER 1965

## FOREWORD

The purpose of Task 9, assigned to the Navy Weather Research Facility, is to develop forecasting rules and operational climatology for specified strategic and tactical areas.

In two previous NWRF reports, [1] and [2], combinations of observed weather elements and an oceanographic parameter were classified as being (a) favorable for or (b) adverse to carrier task force operations. The classification criteria used were based on informal conferences with operational personnel. The weather logs of selected North Atlantic Ocean and North Pacific Ocean station vessels were translated into records of favorable and adverse carrier task force weather. Finally, these records were summarized in the Navy publications in two convenient types of meteorological probabilities by graphs. Examples were included for planning carrier task force operations on or near the locations of the ship reporting stations. Most carrier operations, however, take place in regions of little or no data which are located between widely spaced reporting stations. This publication, therefore, presents empirically derived presentations which allow the user to estimate values of meteorological probabilities for operational application in such data sparse regions.

Among those who aided in the study, Mr. Hermann B. Wobus, Senior NWRF Meteorologist, and Dr. Thomas A. Gleeson, an NWRF consultant, provided technical council. Mr. S. Donald Case, Jr. leader of Task 9, developed the mathematics used to derive the system, supervised the work, and wrote the manuscript for this report. Mr. Francis A. Connor, an NWRF student employee, made valuable suggestions during the investigation and fitted numerous meteorological probability curves calculated for the previous Navy publications. Mrs. Rita F. Gaya, an NWRF mathematician, aided in refining the mathematics. Mr. John M. Mercer, Assistant Chief of the Research Division for Publications, made the final edit.

This report has been reviewed and approved on 29 November 1965 by the undersigned.

James L. Kerr
JAMES L. KERR
Commander, U.S. Navy
Officer in Charge
U.S. Navy Weather Research Facility

## TABLE OF CONTENTS

# LIST OF FIGURES AND TABLES

Page

Figures (90):

## LIST OF FIGURES AND TABLES (CONTINUED)

## LIST OF FIGURES AND TABLES (CONTINUED)

## LIST OF FIGURES AND TABLES (CONTINUED)



Tables (4):

# 1. INTRODUCTION

## 1.1 Providing Data for Operational Planning

Planning carrier task force operations usually requires that selected environmental elements be considered. The planner who desires to account for them, however, frequently finds difficulty; usually no summarized records pertaining to the oceanic area of interest are available to form the basis for a firm decision. Often he must process and refine records that do exist to extract information important for operational planning.

When no data are available, meteorologists must frequently infer relationships from information gathered at adjacent localities. The quality of the inferences, however, generally depends on the distance from the original point of observation and is most reliable at the observation station, growing gradually less reliable with distance. The Navy has devoted considerable time to the problem of refining and summarizing meteorological data to make them more generally useful for operational planning. The publications (a) *U.S. Navy Climatic Atlas of the World*, (b) *Meteorological Probabilities for Planning Carrier Task Force Operations in the North Atlantic* (NWRF 13B-0959-027) [1], and (c) *Meteorological Probabilities for Planning Carrier Task Force Operations in the North Pacific* (NWRF 09-0662-061) [2] partially fulfill the need of appropriate summaries for the planner. The two Navy publications, referenced by brackets, present seasonal collections of meteorological probability graphs for planning carrier air operations at or near selected North Atlantic and North Pacific ship locations. From these graphs a planner may read off and apply probability values of minimum durations of weather (a) suitable or (b) unsuitable for operating aircraft from carriers in these areas. He may determine and use probability values of individual allowance for operations requiring specified durations of weather suitable for such operations. See section 1.4 for the definition of individual allowance. The technical article, *Some Applications of Meteorological Probabilities* [3], published in the December 1962 issue of the *Journal of Applied Meteorology* explores the theory behind meteorological probabilities and their applications. This report, a continuation of the work, provides an objective system for estimating values of each of the two types of meteorological probabilities. These probability estimates may be used for planning carrier operations in data sparse regions of the North Atlantic and North Pacific Oceans.

With these goals in mind, the two types of meteorological probability graphs are briefly reviewed in section 1.3. That part of the system for estimating type I probabilities is explained nonmathematically with examples in chapter 2 with comprehensive examples of application. That part of the system for estimating type II probabilities is similarly explained in chapter 3. Readers interested in the mathematical development and theory of meteorological probability graphs, however, are encouraged to study reference [3].

## 1.2 Review of Meteorological Probability Graphs

References [1] and [2] furnish collections of two types of seasonal probability graphs, as illustrated in figures 1.1 and 1.2, for planning carrier task force operations near nine North Atlantic ship stations (table 1.1) and near nine North Pacific ship stations (table 1.2).

TABLE 1.1. *North Atlantic Ocean Stations Vessels.*

| *SHIP* | *LOCATION* |
|---|---|
| *ALPHA* | *62° N.–33° W.* |
| *BRAVO* | *56° N.–51° W.* |
| *CHARLIE* | *53° N.–35° W.* |
| *DELTA* | *44° N.–41° W.* |
| *ECHO* | *35° N.–48° W.* |
| *HOTEL* | *38° N.–69° W.* |
| *INDIA* | *61° N.–14° W.* |
| *JULIET* | *53° N.–20° W.* |
| *MIKE* | *66° N.–02° E.* |

TABLE 1.2. *North Pacific Ocean Station Vessels.*

| *SHIP* | *LOCATION* |
|---|---|
| *PAPA* | 50° N.–145° W. |
| *NECTAR* | 30° N.–140° W. |
| *OBOE* | 40° N.–142° W. |
| *QUEBEC* | 43° N.–167° W. |
| *SIERRA* | 48° N.–162° E. |
| *UNION* | 26° N.–149° W. |
| *VICTOR* | 33° N.–164° E. |
| *TANGO* | 29° N.–135° W. |
| *EXTRA* | 39° N.–153° W. |

Figure 1.1 illustrates a typical type I meteorological probability graph. It consists of two probability curves which relate minimum duration of favorable weather (dashed curve) and adverse weather (solid curve) to their corresponding probabilities of occurrence. The vertical axis (ordinate) is scaled in *Probability Percentage* from zero to 100 percent, and the horizontal axis (abscissa) is scaled in *Duration (Hours)* from zero to 350 hours. Type I graphs may be used to answer the following questions:

1. Provided the weather has just become favorable (or adverse), a period of *at least* what length of favorable (or adverse) weather may be expected with a specified probability of occurrence?

2. What is the probability that a period of favorable (or adverse) weather, once started, will endure at least a preassigned period of time?

3. What is the probability that favorable (or adverse) weather a known number of hours old will remain so for at least another specified period?

4. What is the conditional probability (defined in section 1.4) that a length of favorable (or adverse) weather will fall between two specified periods of time?

Figure 1.2 shows a typical type II meteorological probability graph. It contains five solid curves and a dashed line. The five solid lines, arching from left to right, refer to operations requiring five specific lengths of uninterrupted favorable weather (i.e.; 3, 12, 24, 48, and 72 hours). Each solid curve is appropriately labeled. The dashed line sloping downward from left to right is the focus of the operation curves just described. As in graph type I (fig. 1.1), the ordinate depicts *Probability Percentage* however, the abscissa depicts *Individual Allowance (Hours)* values scaled from zero to 420 hours. The probability of a specified favorable weather period falling within a desired allowable time on station (individual allowance) may be read directly from the vertical axis by using the appropriate operation curve. The dashed line on a given type II graph yields probability values of obtaining specified lengths of favorable weather immediately when a vessel arrives in the operation area having favorable environmental conditions. For any point on the dashed curve, the individual allowance equals the operation period.

When the seasonal probability graphs [1 and 2] were made for each station ship listed above, the first step was to assign weather elements of ceiling, visibility, wind force, and sea state reported in each 3-hourly ship observation to categories (operable, marginal, and inoperable) given in table 1.3.

The weather reported by each of these observations was then classified under criteria in table 1.4 as being (a) favorable for or (b) adverse to carrier air operations. Environmental conditions applying to a carrier which operates one type of aircraft may be invalid when another type of aircraft is operated. The operational criteria governing the *favorable* and *adverse* categories in this report, however, are considered valid for most carrier operations. Finally, graphs of type I were derived from seasonal frequency distributions of such favorable and adverse weather periods in the ship station records of 3-hourly observations. The type II graphs were made from seasonal frequency distributions of individual allowances calculated for each of these observations.

### 1.3 Data Presentation

This report presents an objective system of operational presentations for estimating each of the two types of meteorological probabilities described in section 1.2 above. These estimates may be used for planning carrier air operations in sparse data regions of the North Atlantic and North Pacific Oceans the same as if actual meteorological probabilities were calculated for

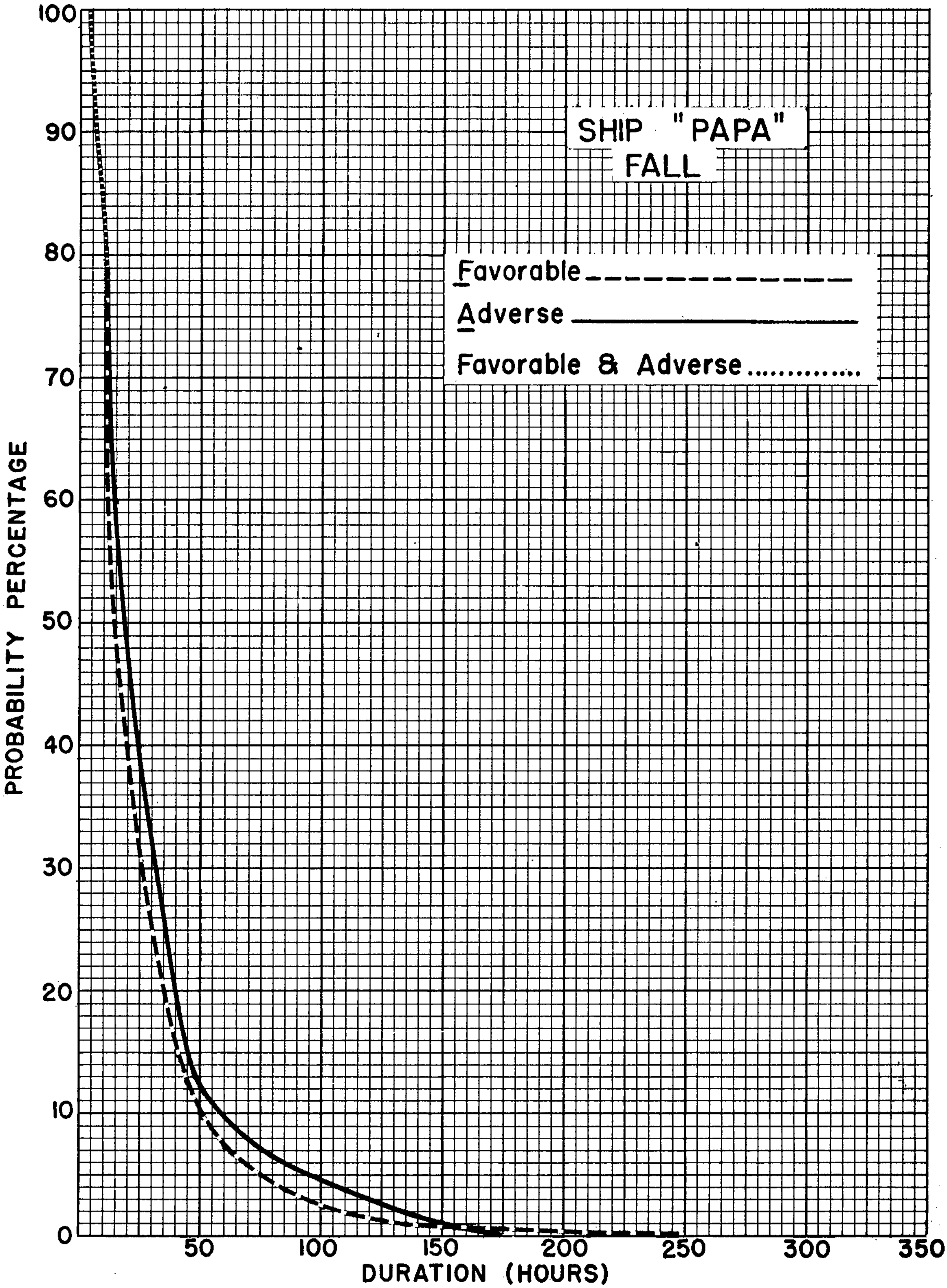



*Figure 1.1 Probability of Duration of Favorable and Adverse Operational Weather: Ships "Papa" – Fall (Graph Type I).*

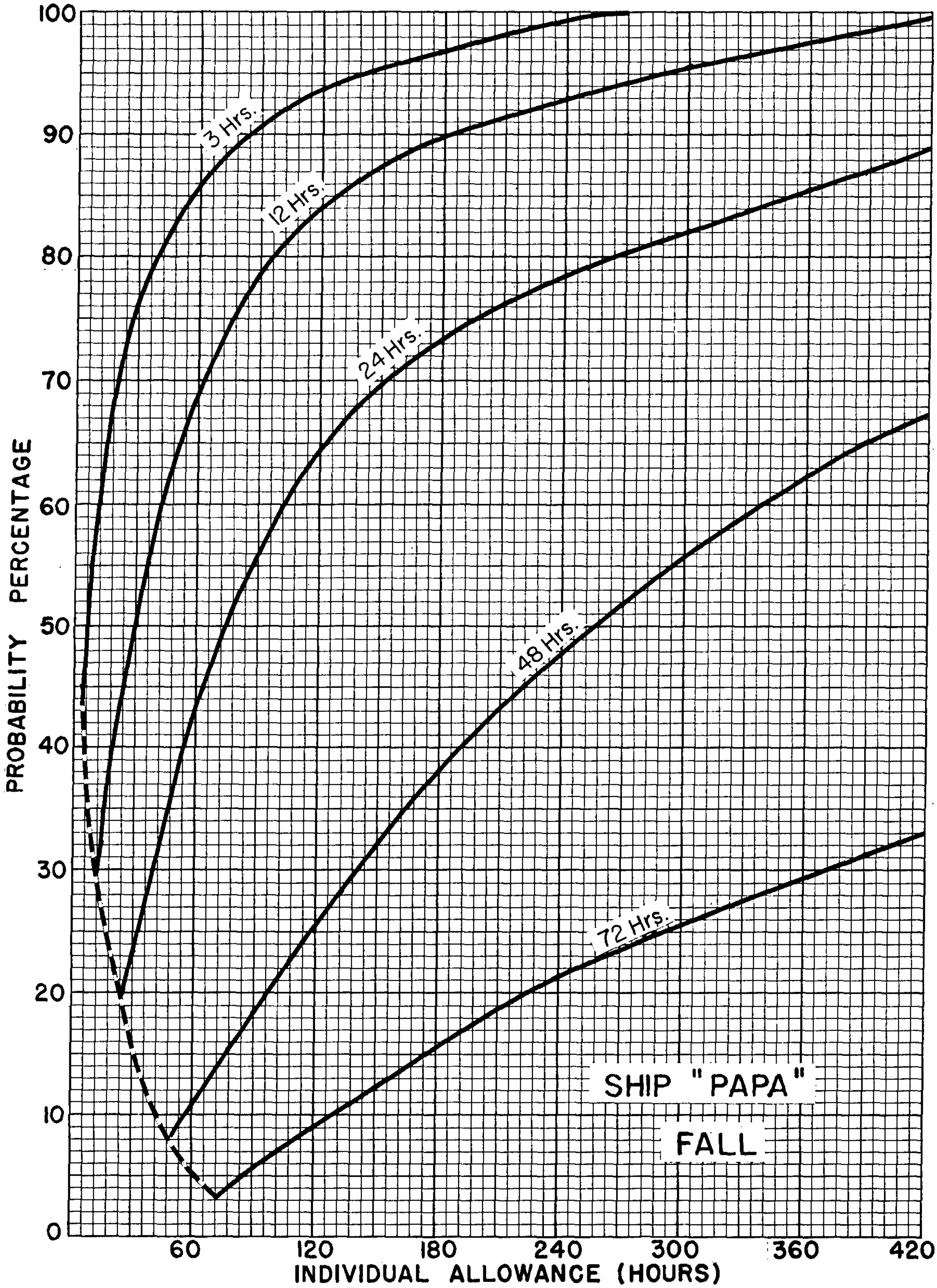



*Figure 1.2 Probability of Favorable Period Within a Given Individual Allowance of Specified Durations: Ship "Papa" – Fall (Graph Type II).*

TABLE 1.3. *Categorical Limits for Assignment of Elements.*

| | CEILING (Feet) | SEA HEIGHT (Feet) | VISIBILITY (Miles) | WIND FORCE (Knots) |
|---|---|---|---|---|
| Operable: | above 2,000 | below 5 | above 3 | 6 to 27 |
| Marginal: | 300 to 2,000 | 5 to 12 | 1 to 3 | 28 to 40 and below 6 |
| Inoperable: | below 300 | above 12 | below 1 | above 40 |

these regions. The first part of the system was developed for estimating type I graphs, and the second part for estimating type II graphs. Each of the parts employs two separate but similar sets of presentations (fig. 1.3). The first set of presentations consists of a group of analyzed maps of the North Atlantic and North Pacific Oceans. These maps depict seasonal analyses of two parameters that are related to the type of graphical probability curve desired. Figures 2.2 and 2.4 of chapter 2 illustrate typical operational maps for estimating type I curves, and figures 3.2 and 3.3 of chapter 3 illustrate such maps for estimating type II curves. The second set of operational presentations for estimating each curve type consists of curve families that correspond to assigned values of the two pairs of associated parameters. Chapters 2 and 3 also describe example applications using these probability curve estimates.

TABLE 1.4. *Criteria for Classification of Observations.*

| | |
|---|---|
| Favorable | — *Not more than three (3) of the observed elements fall into the "marginal" category of table 1.3; the other(s) being classified "operable."* |
| Adverse | — *One (1) or more of the observed elements fall into the "inoperable" category of table 1.3, or four (4) fall into the "marginal" category.* |

### 1.4 Definitions

*Adverse*— Adverse signifies any combination of meteorological and oceanographic parameters which severely restrict attack carrier operations. The parameters considered to be adverse are provided in tables 1.3 and 1.4.

*Conditional Probability* — Conditional probability in this publication refers to the probability, $P(B/A)$, that event B will occur based upon the condition that event A has already transpired. $P(B/A)$ may be given by

$$P(B/A) = \frac{N\,(A \text{ and } B)}{N\,(A)} \qquad (1.1)$$

where $N(A)$ is the number of occurrences in a sample of observed data giving rise to event A, and $N(A \text{ and } B)$ is the number of occurrences giving rise to both event A and event B. By dividing both the numerator and the denominator of equation 1.1 by N, the total number of occurrences (see the definition of probability below), one may obtain

$$P(B/A) \quad \frac{N(A \text{ and } B)/N}{N(A)/N} = \frac{P(A \text{ and } B),}{P(A)} \qquad (1.2)$$

in which $P(A \text{ and } B)$ is the probability that both events A and B will take place, and $P(A)$ is the probability that event A will occur.

*Duration*— Duration denotes the length of time in hours during which a specified environmental or operational condition exists without change; e.g., for favorable conditions persisting $n$ successive 3-hourly observations, the duration of the favorable condition is 3 $n$ hours.

*Favorable*— Favorable indicates those combinations of meteorological and oceanographic parameters which do not restrict attack carrier air operations. These combinations are furnished in tables 1.3 and 1.4.

*Individual Allowance*— Individual allowance is the period between the arrival of a ship in an oceanic area and the end of a specified length of uninterrupted favorable weather in that location. Note that an individual allowance value is numerically equal to the waiting period plus the length of favorable weather. The term was derived from the fact that an individual allowance is the *a priori* estimate of the total time an *individual* ship or group of ships must *allow* (plan to spend in area) to complete an operation requiring the specified unbroken period of favorable operating conditions.

*Probability*— Probability in this study indicated the degree of certainty that a desired event will occur based upon climatology. The probability, $P(A)$, that event A will come about may be expressed mathematically by

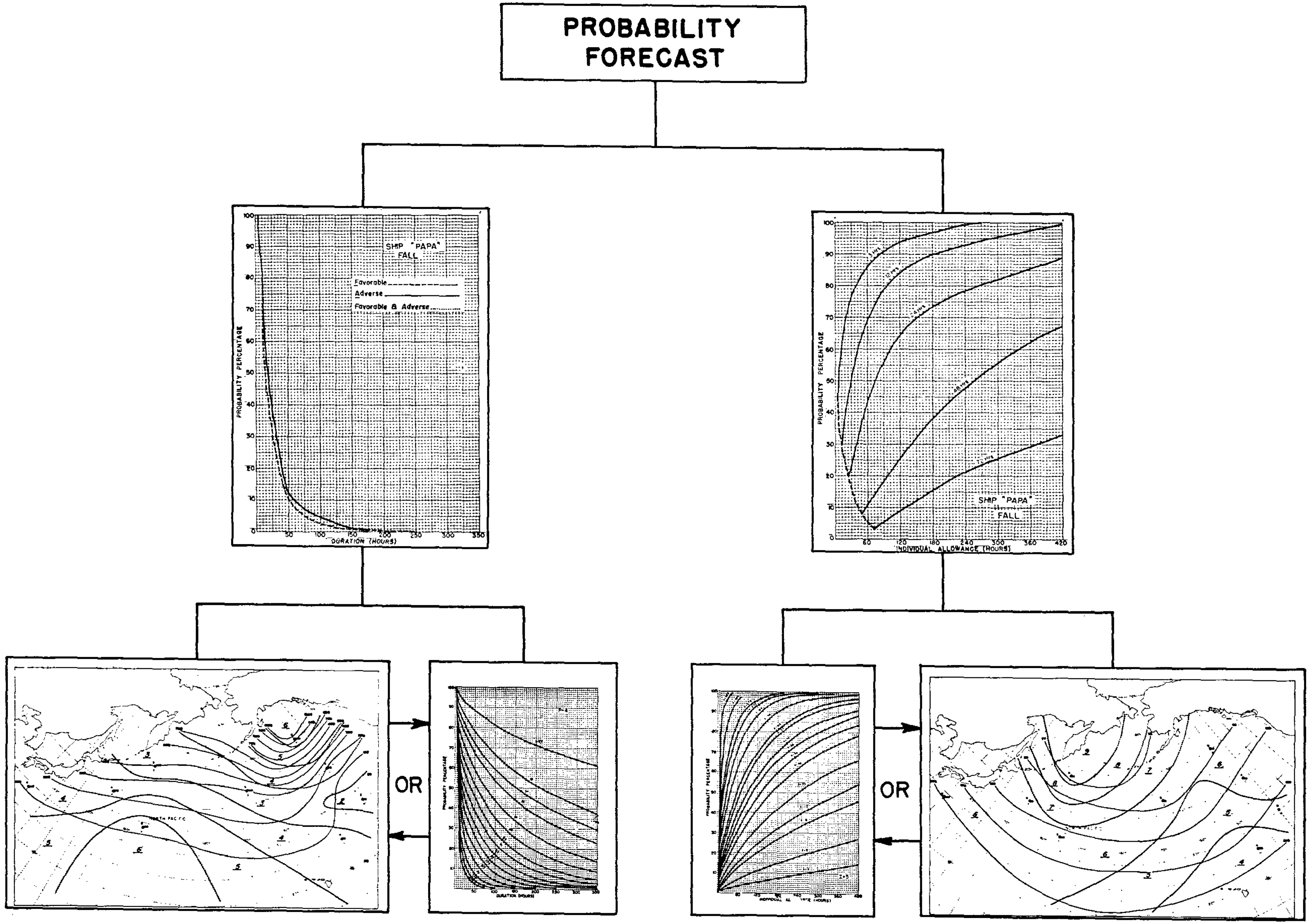



Figure 1.3 Flow Diagram of Probability Forecast Aids.

$$P(A) = \frac{N(A)}{N}, \qquad (1.3)$$

where $N(A)$ is the number of occurrences giving rise to event $A$ in a sample of observed meteorological data, and $N$ is the total number of occurrences in the sample.

*Season* -- Season signifies the four usual subdivisions of the year—winter, spring, summer, and fall. In this report the seasons are: Winter—December, January, February; Spring—March, April, May; Summer--June, July, August; and Fall—September, October, November.

*Waiting Period* -- Waiting period denotes the length of time between the arrival of a ship in an oceanic area and the beginning of a period of favorable weather of specified length in that locality.

## 2. TYPE I PROBABILITY CURVES

### 2.1 Description and Interpretations

References [1] and [2] provide a complete seasonal collection of type I probability duration curves for planning carrier task force operations near selected North Atlantic and North Pacific ocean station vessel locations (listed in tables 1.1 and 1.2, chapter 1). This chapter presents a full set of operational data presentations for estimating such type I probability duration curves.

The data was derived from values resulting when the existing type I probability curves, referred to above, were fitted empirically with curves generated with two mathematical parameters, P and D (Probability-Duration). The data are divided into two parts. The first part consists of a special set of 16 maps. The second part is made up of a set of 5 curve families especially prepared for this publication. Section 2.2 presents examples of data application. Section 2.3 presents the entire set of maps, and section 2.4 presents the complete collection of curve families.

Virtually all of the original type I probability duration curves for both favorable and adverse weather conditions were fitted with generated curves to an acceptable tolerance-of-error of 5 percent. Values were assigned to the P and D parameters described above so that the values uniquely identify the type I curve fits. Figure 2.1 portrays a typical family of curves generated with many D values paired with a single P value of 2.

Note that many values of D but only 5 P values (i.e., 2, 3, 4, 5, and 6) were employed in fitting the real curves [1 and 2]. The vertical axis is scaled in "Probability Percentage" from zero to 100 percent and the horizontal axis in "Duration (Hours)" from zero to 350 hours. This format is the same one used in the original graphs (fig. 1.1). Generated curves, like their real couterparts, slope asymptotically downward toward the right from a common point where probability percentage equals 100 percent and duration equals 3 hours; taking into account that only 3-hour reports were employed in making the original graphs (chapter 1). Note in the figure that curves of high D values are located near the bottom of the graph and curves of low values are located near the top. Thus, such generated curves of relatively low D values relate relatively high probabilities for given

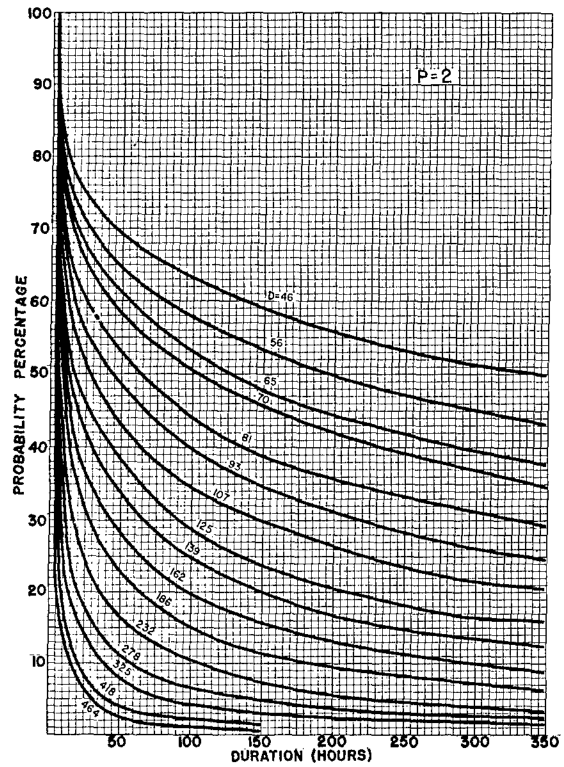



*Figure 2.1 Type I Probability Duration D Curves (Generated): P Value of 2.*

durations of favorable (or adverse) weather conditions. Conversely, curves of relatively high D values relate relatively low probabilities. D is considered the primary parameter and P the secondary parameter in applying type I curve families, as described in section 2.2.

The first part of the operational data is presented in section 2.3 in the form of seasonal maps depicting analyses of the P and D values used to fit the original graph curves. Figures 2.2 and 2.3 provide two typical examples of such analyses for favorable and adverse weather durations. The P and D values were plotted on surface maps in accord with the model given in figure 2.4 and analyzed. The fields of parameters P and D in figures 2.2 and 2.3 were separately analyzed. A field of primary parameter D is a continuous scalar field like that of pressure on a surface map or temperature on a constant pressure map. The fields of parameter D were therefore analyzed for significant values with isopleths of thin solid lines. The reader may extract D values for a given area from the maps

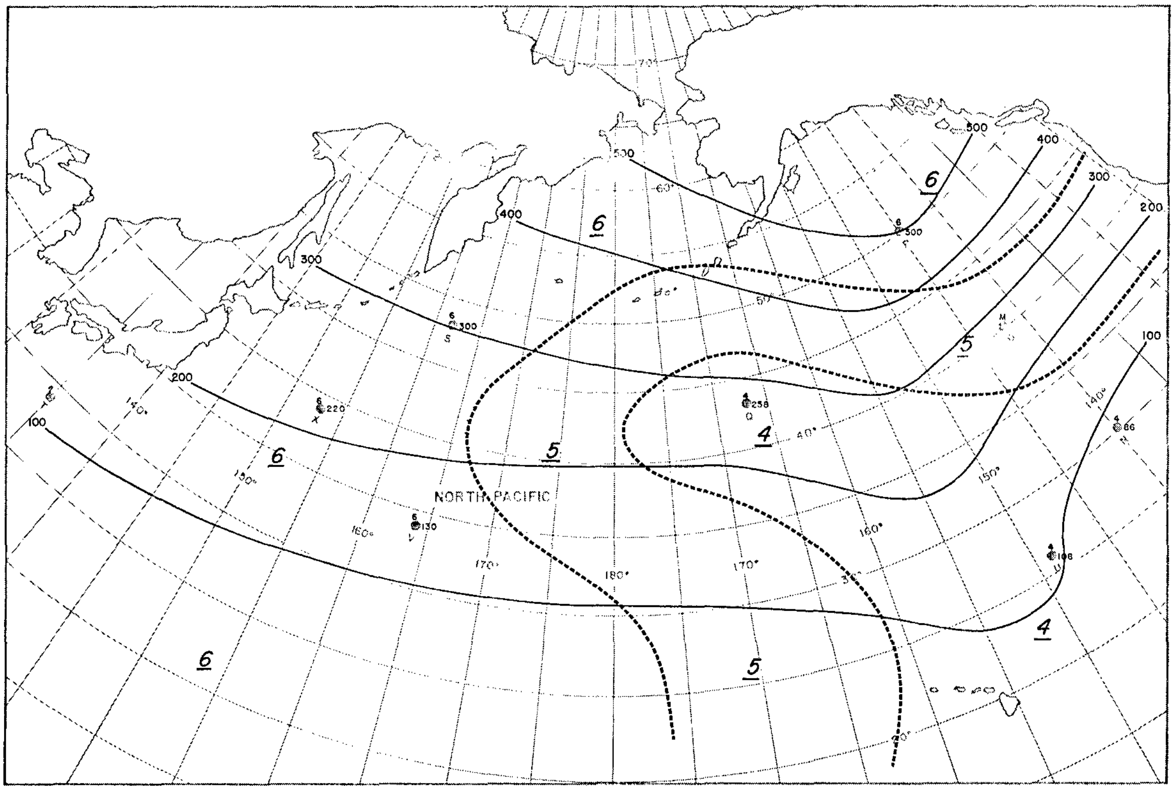



*Figure 2.2 Analyses of P and D Values: North Pacific Ocean – Fall – Favorable Weather.*

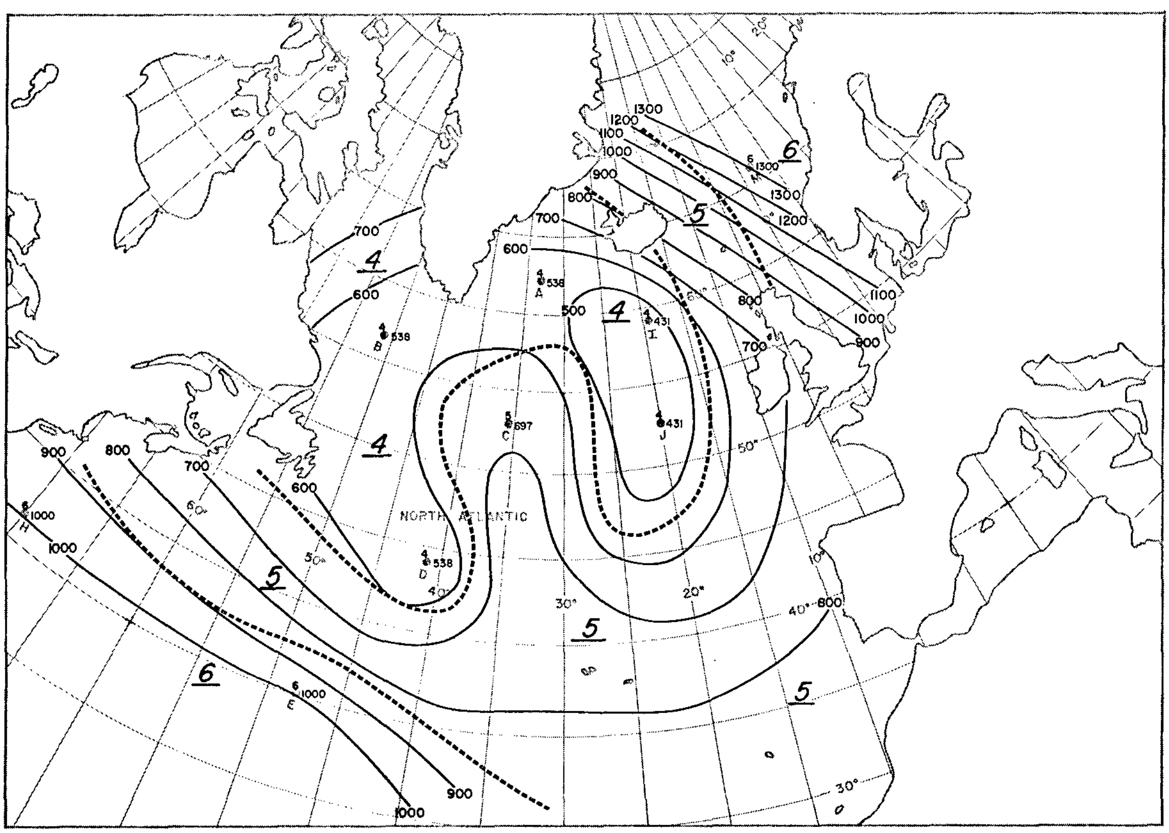



*Figure 2.3 Analyses of P and D Values: North Atlantic Ocean – Summer – Adverse Weather.*

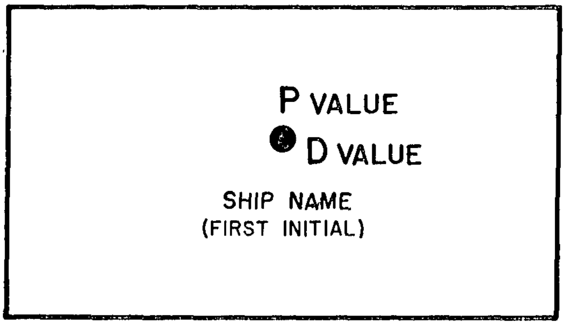



*Figure 2.4 Plotting Model – P and D Values.*

by interpolating linearly between isopleths. The field of secondary parameter P is not a continuous scalar field. The P field, however, may be analyzed by separating it into homogeneous areas of equal values with heavy dashed lines. Each P area in the figure is assigned a value of 4, 5, or 6, depending on the plotted data. Other maps in the series, of which this example is one, contain P values of 2, 3, 4, 5, or 6, depending on individual map data. All P values are clearly labeled with large slanted numbers. P values may be extracted from a map by assuming that all locations lying in a given area receive the same P value (i.e., the value assigned to the area). A location on a map that lies on a heavy dotted line separating two adjacent P areas, however, receives the P value of the lower value area. For example, a point on the boundary between a P area of 4 and a P area of 5 would receive the value of 4. Section 2.2 describes applications of the presentation with examples.

Note that maps such as those shown in figures 2.3 and 2.4 may be interpreted meteororologically. The highest probabilities of specified durations of favorable (or adverse) weather occurring may be expected in regions delineated by isopleths of minimum D values, subject to the modifying effect of secondary parameter P. Conversely, the lowest probabilities of such durations may be expected in regions delineated by isopleths of maximum D values, also subject to the modifying effect of P. Section 2.3 contains a complete set of 8 seasonal map analyses suitable for use in estimating type I meteorological probabilities in each of the North Atlantic and North Pacific Oceans (4 seasons and 2 weather categories). The second part of the operational data (section 2.4) is made up of 5 families of generated type I probability duration curves like the family depicted in figure 2.1. They were generated with many parameter D values and 5 parameter P values (2, 3, 4, 5, and 6). The set, therefore, consists of a curve family for each of the 5 P values.

When the user estimates a type I curve, the D value that is interpolated from a map, as described above, establishes the primary curve estimate. The P value, also read off the map, refines the primary estimate to obtain a final composite curve. A planner may estimate a type I probability duration curve for a selected area. He then:

1. Extracts seasonal values of parameters P and D from the appropriate map in section 2.3, as discussed above.

2. Interpolates a curve that matches the extracted values from an appropriate curve family out of the set in section 2.4.

### 2.2 Applications

Typical problems and their solutions are offered as a reference in estimating type I probability duration curves and applying these curve estimates in operational planning. The techniques involved, refer to any specified North Atlantic Ocean or North Pacific Ocean locality and to favorable weather or adverse weather durations during any climatic season as defined in chapter 1, paragraph 1.4. Applications examples of the method are presented in two parts. The first part is concerned only with the estimation of curves and the second, with applications of these estimates in operational planning.

#### 2.2.1 *Estimating Type I Probability Curves*

Example 1: Probable duration curve of favorable weather for a specified area.

Problem 1:
Estimate a type I probable duration curve of favorable weather at 40° N. latitude and 30° W. longitude in the North Atlantic during winter.

Solution:
Consult the North Atlantic winter map of analyzed P and D parameter values for favorable weather durations (fig. 2.9 on page 15, section 2.3) and find the location specified. Note that this locality falls in a P-area value of 4. It also lies between the 200 value D isopleth and the 300 value isopleth. Interpolate lineraly between the two isopleths to obtain a D

value; then read off the P value of the associated P area. For the location specified the reader should obtain a P value of 4 and a D value of 285.

To estimate a type I probability curve of favorable weather duration, look up the set of curves for a P value of 4 (fig. 2.5 or fig. 2.27). Note that the curve for D value of 285 should fall between the curves for D values 258 and 323. Interpolate logarithmically between the two curves and draw the curve wanted on the printed family set (see fig. 2.5).

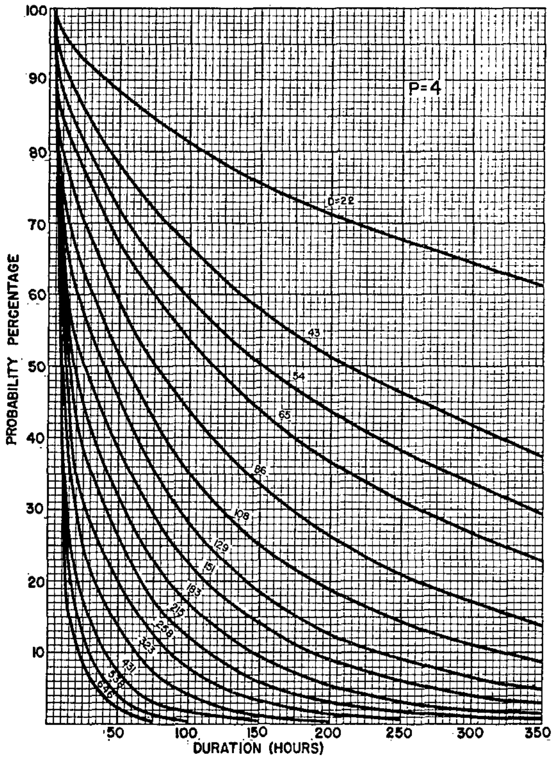



*Figure 2.5 Type I Probability Duration D Curves (Generated): P Value of 4.*

Problem 2:
Estimate a type I probable duration curve of favorable weather durations at 44.8° N. latitude and 151.8° W. longitude in the North Pacific during summer.

Solution:
Consult the North Pacific summer map of analyzed P and D values for favorable weather durations (fig. 2.6) and concentrate on the location at 44.8° N. latitude and 151.8° W. longitude. This location falls *on the boundary* separating a P area of 4 and a P area of 5. Therefore, select the *lower* P value for the locality being considered (i.e., 4). The locality also lies directly on the 600 D isopleth, so select a D value of 600.

To estimate the type I curve desired, seek out the timely curves for a P value of 4 (fig. 2.5). The curve for a D value of 600 should lie between the curves for D values of 538 and 646 in the family. The curve wanted, may be drawn lightly in pencil on the printed curve family after interpolating logarithmically between the two D curves.

Example 2: Probable duration curve of adverse weather for a specified area.

Problem 1:
Estimate a type I probability curve of adverse weather for operating in a region at 45° N. latitude and 40° W. longitude in the North Atlantic during spring.

Solution:
Consult the spring North Atlantic map of analyzed P and D values for adverse durations (fig. 2.7) and look at the location specified. Note that this locality lies within a P area with a value of 6. It also falls between the 375 D isopleth and 400 D isopleth. By interpolating linearly between these two D isopleths and extracting directly the value of the associated P area, the reader should obtain a P value of 6 and a D value of 397.

To extract a type I curve estimate, consult the set of curves for a P value of 6 (fig. 2.8). The curve for D equals 397 lies between the curves for D values of 300 and 400. The desired curve may be sketched lightly in pencil on the printed set after interpolating logarithmically between the two D curves (see fig. 2.8).

Problem 2:
Estimate a type I probable duration curve of adverse weather durations at 46.2° N. latitude and 158.9° E. longitude in the North Pacific during fall.

Solution:
Look up the North Pacific fall map of analyzed values for adverse weather durations (fig. 2.24) and notice the area spec-

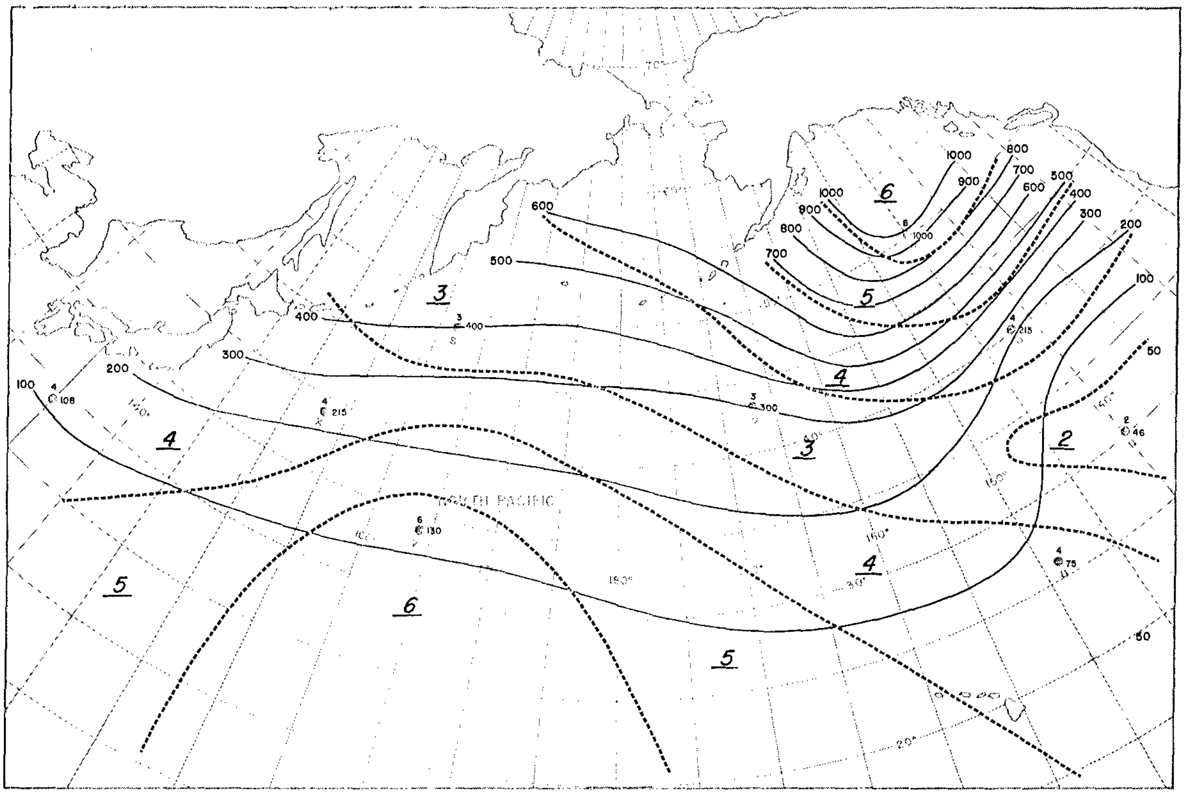



Figure 2.6 Analyses of P and D Values: North Pacific Ocean – Summer – Favorable Weather.

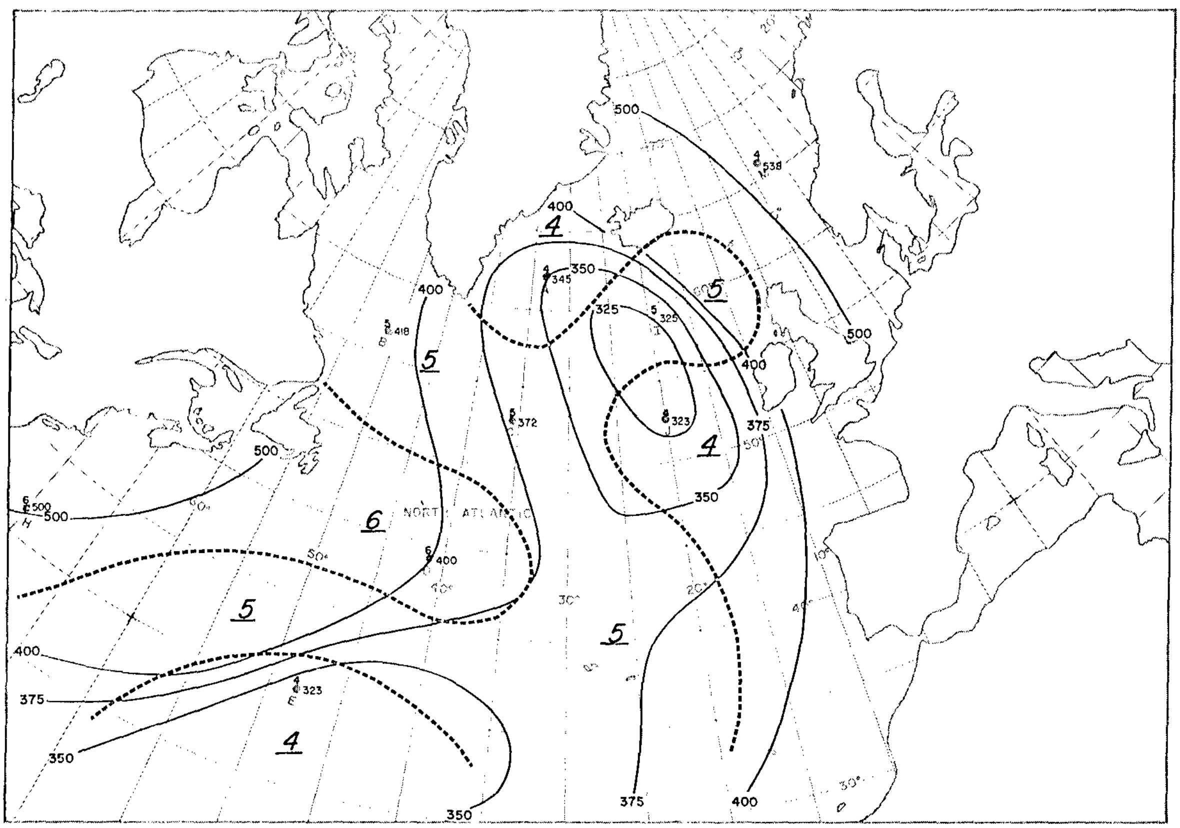



Figure 2.7 Analyses of P and D Values: North Atlantic Ocean – Spring – Adverse Weather.

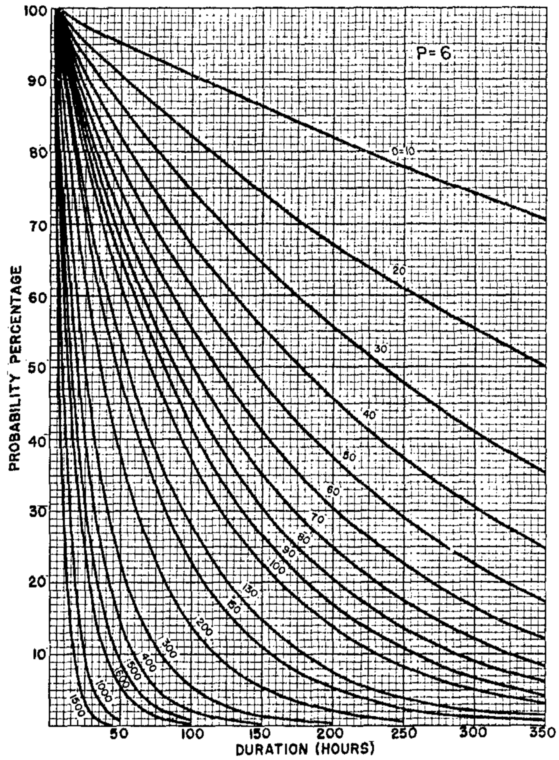



*Figure 2.8 Type I Probability Duration D Curves (Generated): P Value of 6.*

ified. The area lies *on the boundary* separating a $\bar{P}$ area of 4 and a $\bar{P}$ area of 5. Select the *lower* P value of 4 for the locality. The area also falls on the 300 $\bar{D}$ isopleth, so choose a D value of 300.

To obtain the desired curve estimate, consult the set of curves for a $\bar{P}$ value of 4 (fig. 2.5). The curve for a $\bar{D}$ of 300 in this set should lie somewhere between the curves for $\bar{D}$ values of 258 and 323. Sketch the curve lightly in pencil on the printed set after interpolating logarithmically between the two $\bar{D}$ curves.

### *2.2.2 Applying Type I Curve Estimates*

a. Problems Using Single Probability Values

Example 1: Planning requiring favorable weather.

Problem 1:
For transit through 40° N. latitude and 30° W. longitude during winter (see problem 1, example 1, section 2.2.1 above) favorable weather is required. If the weather has just become favorable calculate the probability that these conditions will continue for *at least* 12 hours. Also, determine the probability of the favorable conditions enduring *less than* 12 hours.

Solution:
Estimate the type I probable duration curve required for favorable weather durations (problem 1, example 1, section 2.2.1 above). Read the ordinate value corresponding to the intersection of the curve estimate and the 12-hour duration value line. The ordinate value indicates that the probability is 57 percent that favorable conditions once commencing will persist at least 12 hours. To calculate the probability of the favorable conditions prevailing *less than* 12 hours under the stated conditions, subtract 57 percent from 100 percent. The required probabality of adverse weather recurring sometime within the 12-hour period is, therefore, 43 percent.

Problem 2:
For planning an air operation at 44.8° N. latitude and 151.8° E. longitude in the North Pacific during summer (problem 2, example 1, section 2.2.1 above) the commander will know the starting time of favorable weather. He will also accept a probability of 60 percent that this condition will hold. How long may favorable weather conditions be expected to last, given this probability?

Solution:
Estimate the type I probable duration curve for favorable weather conditions (problem 2, example 1, in section 2.2.1 above). The ordinate value intersecting the 60 percent probability line and the estimated curve indicates that at least 6 hours of uninterrupted favorable weather may be expected.

Example 2: Planning requiring adverse weather. The procedures set forth in example 1 above also apply when planning operations requiring adverse weather. Merely substitute the word "adverse" for "favorable" in the text and proceed as otherwise directed.

b. Special Probability Problems

Example 1: Calculating the probability that favorable weather a known number of hours old will remain that way for another specified duration.

Problem 1:
Given that the weather became favorable 12 hours ago at 40° N. latitude and 30° W. longitude during winter (problem 1, example 1, section 2.2.2 above), calculate the probability of the favorable weather lasting at least another 24 hours. Also calculate the probability that adverse weather will recur sometime during the 24-hour period.

Solution:
In a given collection of observed favorable weather records which persist at least $D_p$ hours, a certain number of them will extend an additional $D_n$ hours. Dividing this number by the sum of the favorable periods in the group that endure at least $D_p$ hours yields the conditional probability, $P(D_n)$ that favorable weather $D_p$ hours old will remain so for at least another $D_n$ hours. Thus, calculation of $P(D_n)$ may be expressed for this problem by,

$$P(D_n) = \frac{P(D_p + D_n)}{P(D_p)} \qquad (2.1)$$

where $P(D_p)$ read from the curve estimate, is the probability that favorable weather conditions once starting will endure at least $D_p$ hours (see example 1, problem above). $P(D_p + D_n)$, also read from the curve estimate, is the probability of the favorable weather persisting a total period of at least $D_p + D_n$ hours. Applying equation (2.1), the reader may calculate the answer for the given problem from the curve estimate in the form,

$$P(\text{next } 24) = \frac{P(\text{total } 36)}{P(\text{past } 12)} = \frac{24}{33} = 73 \quad \text{percent.}$$

$Q(\text{next } 24)$, the probability that the favorable weather will revert to adverse sometime during the next 24 hours, may be calculated in the form,

$Q(\text{next } 24) = 100 - P(\text{next } 24) = 100 - 73 =$ 27 percent.

Example 2: Calculate the probability that favorable weather, once starting, will end sometime between to specified periods.

Problem:
During summer at 44.8° N. latitude and 151.8° E. longitude (see problem 2, example 1, section 3.2.1 above) the weather became favorable. What is the probability of the favorable weather ending sometime between 6 and 18 hours after it started?

Solution:
A certain percentage of a selected sample of observed favorable weather periods endures at least $D_A$ hours, and another percentage endures at least $D_B$ hours. The difference between these percentages is the percentage of periods in the sample lasting between $D_A$ hours and $D_B$ hours. Consequently, this difference provides the probability, $P(D_B - D_A)$, that a period of weather once becoming favorable will prevail between $D_A$ and $D_B$ hours. Thus, $P(D_B - D_A)$ may be expressed by,

$$P(D_B - D_A) = P(D_A) - P(D_B) \qquad (2.2)$$

where $P(D_A)$ and $P(D_B)$ are probability percentages extracted from an estimated type I probable duration curve, as described in the examples above. Estimate the desired type I probability curve (section 3.2.1, example 1, problem 1) and apply equation (2.2) to the stated problem. Thus, $P(D_{18} - D_{D6}) = P(D_6) - P(D_{18}) = 60 - 12 = 48$ percent.

## 2.3 Type I Curve Map Collection

This section presents 16 seasonal maps of analyzed $\bar{P}$ and $\bar{D}$ values for the North Atlantic and North Pacific Oceans. These maps are shown as figures 2.9 through 2.16 for the North Atlantic and figures 2.17 through 2.24 for the North Pacific Oceans.

## 2.4 Probability Duration Curve Collection

This section presents 5 sets of generated curve families for given P and $\bar{D}$ values. The curves are shown in figures 2.25 through 2.29.

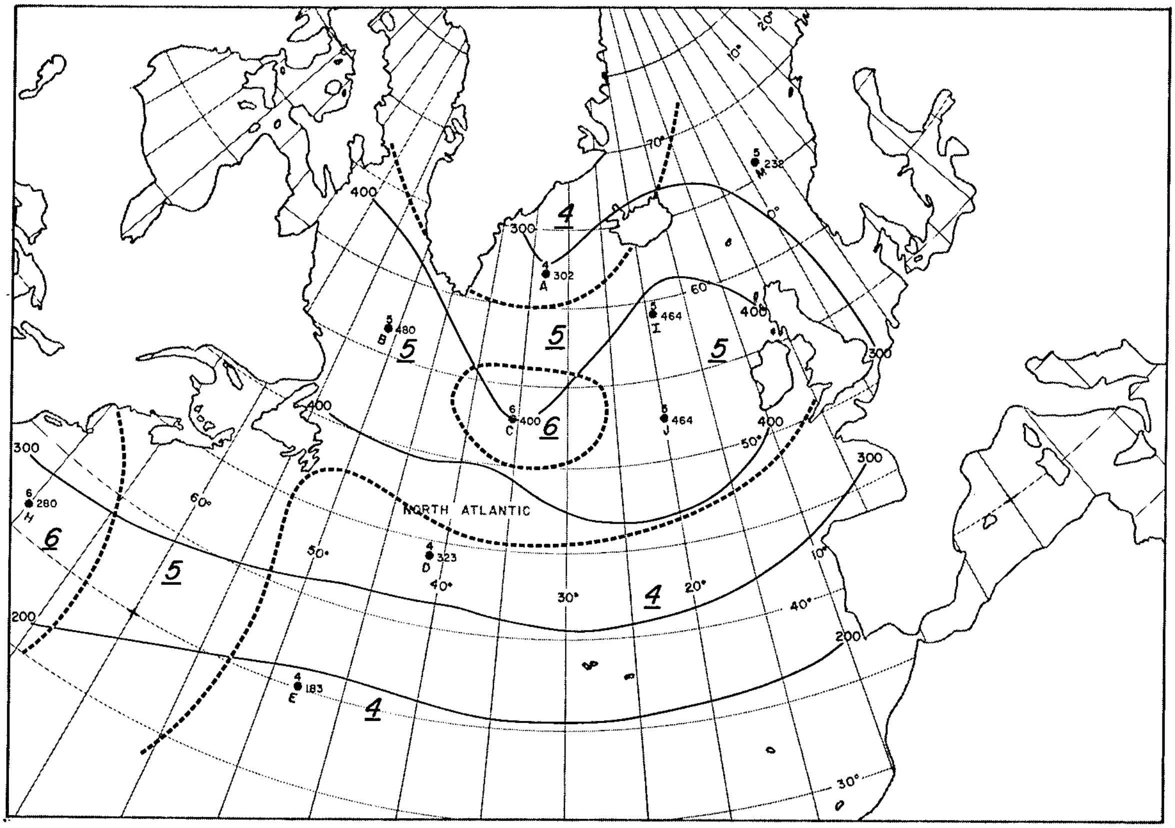



Figure 2.9 Analyses of P and D Values: North Atlantic Ocean – Winter – Favorable Weather.

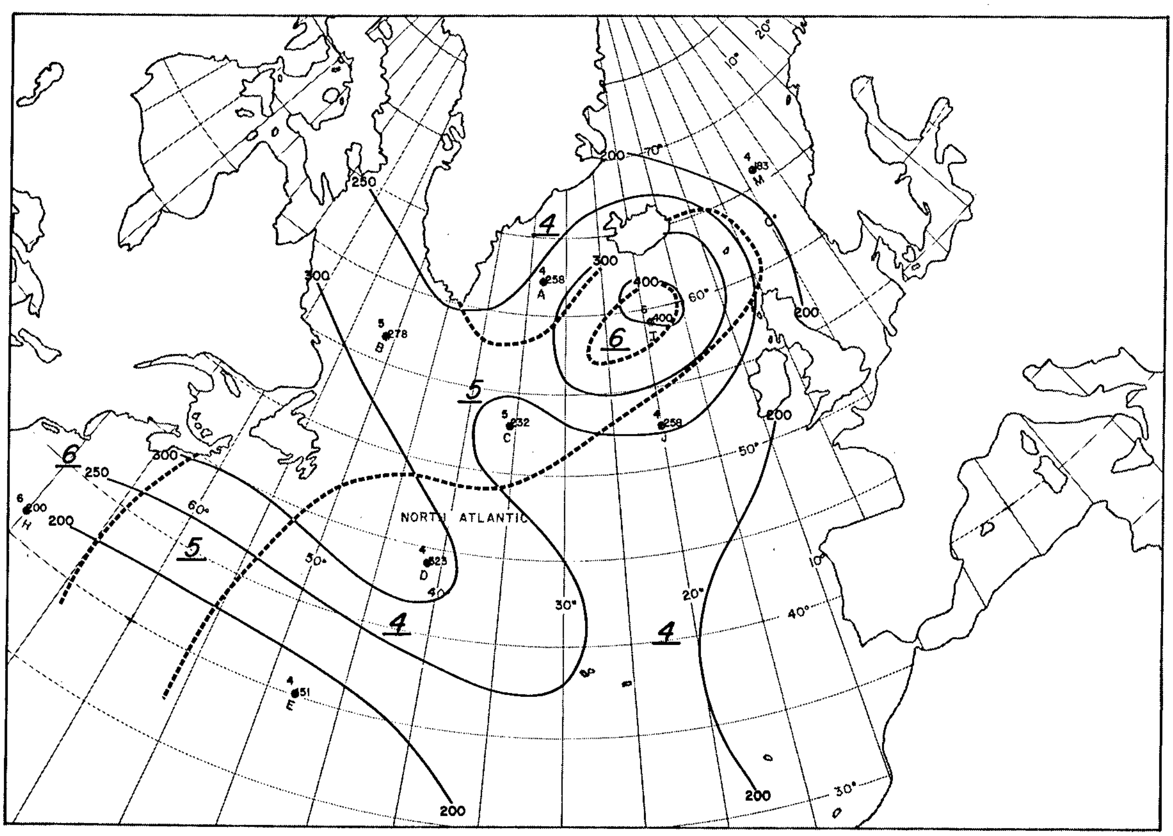



Figure 2.10 Analyses of P and D Values: North Atlantic Ocean – Spring – Favorable Weather.

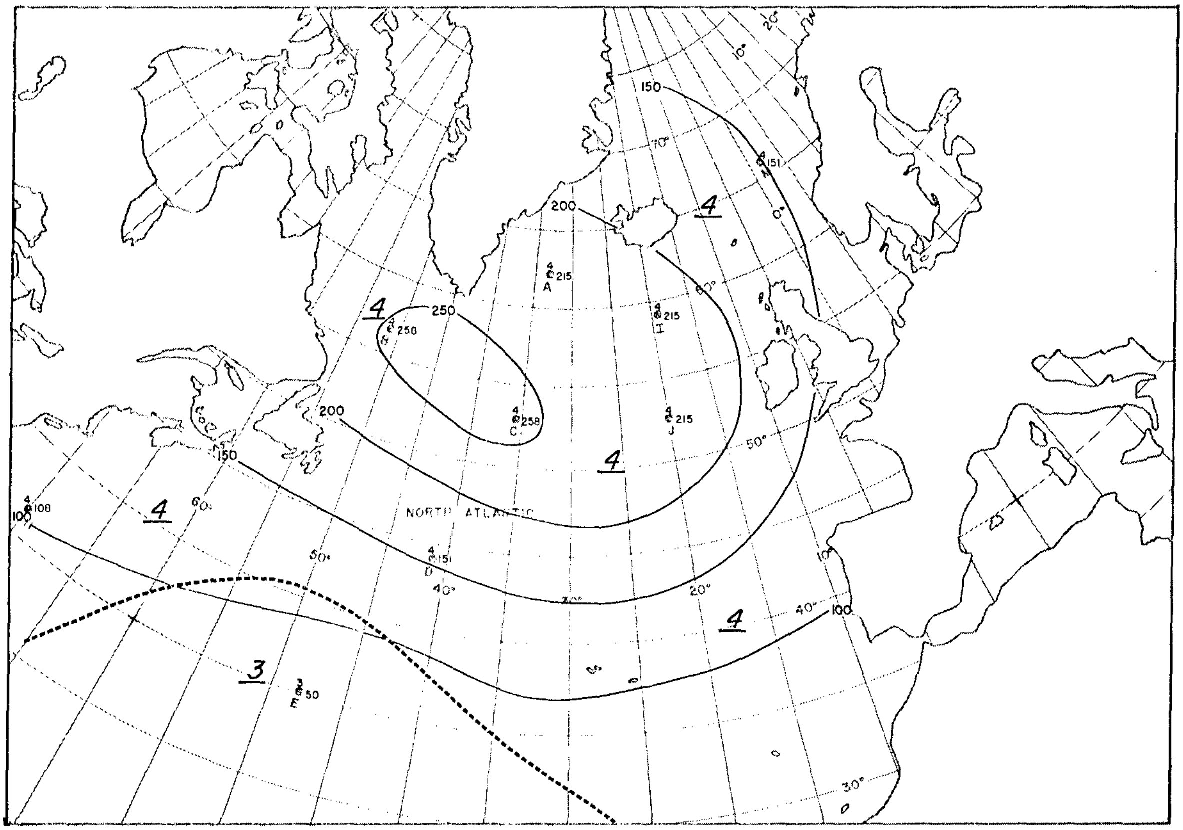



Figure 2.11 Analyses of P and D Values: North Atlantic Ocean – Summer – Favorable Weather.

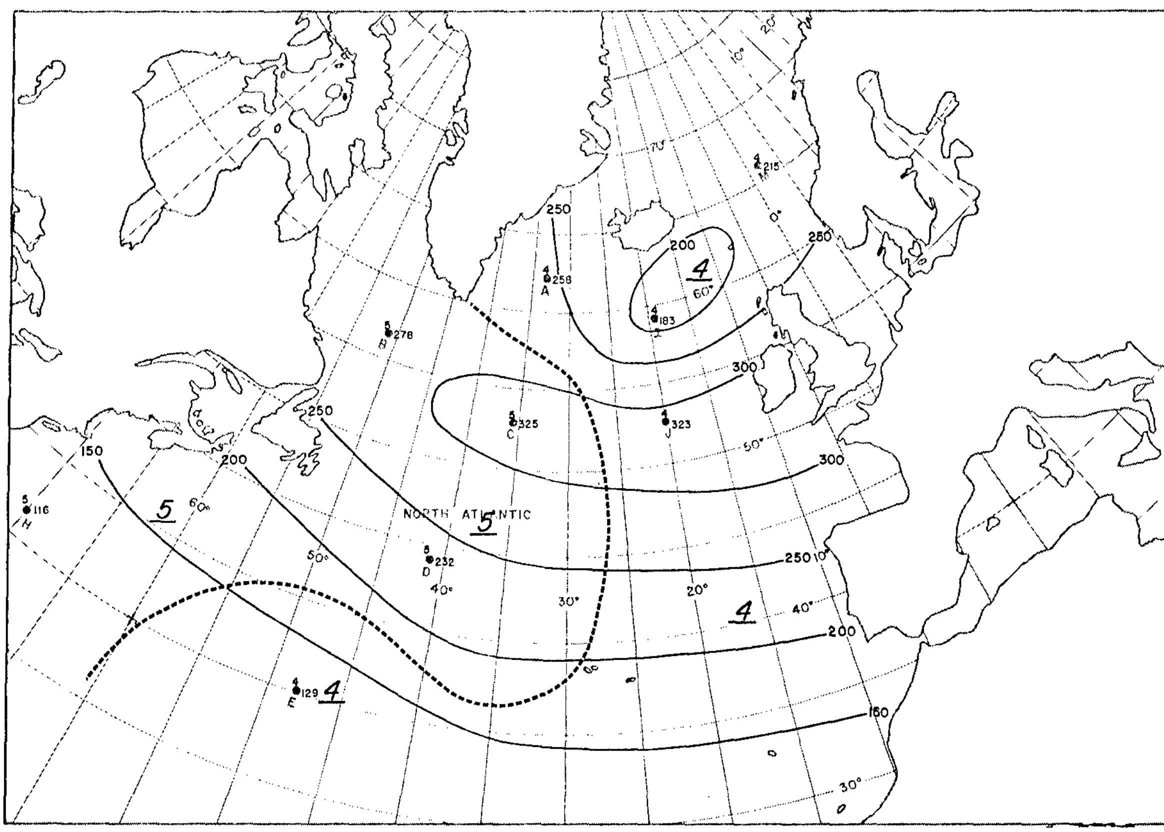



Figure 2.12 Analyses of P and D Values: North Atlantic Ocean – Fall – Favorable Weather.

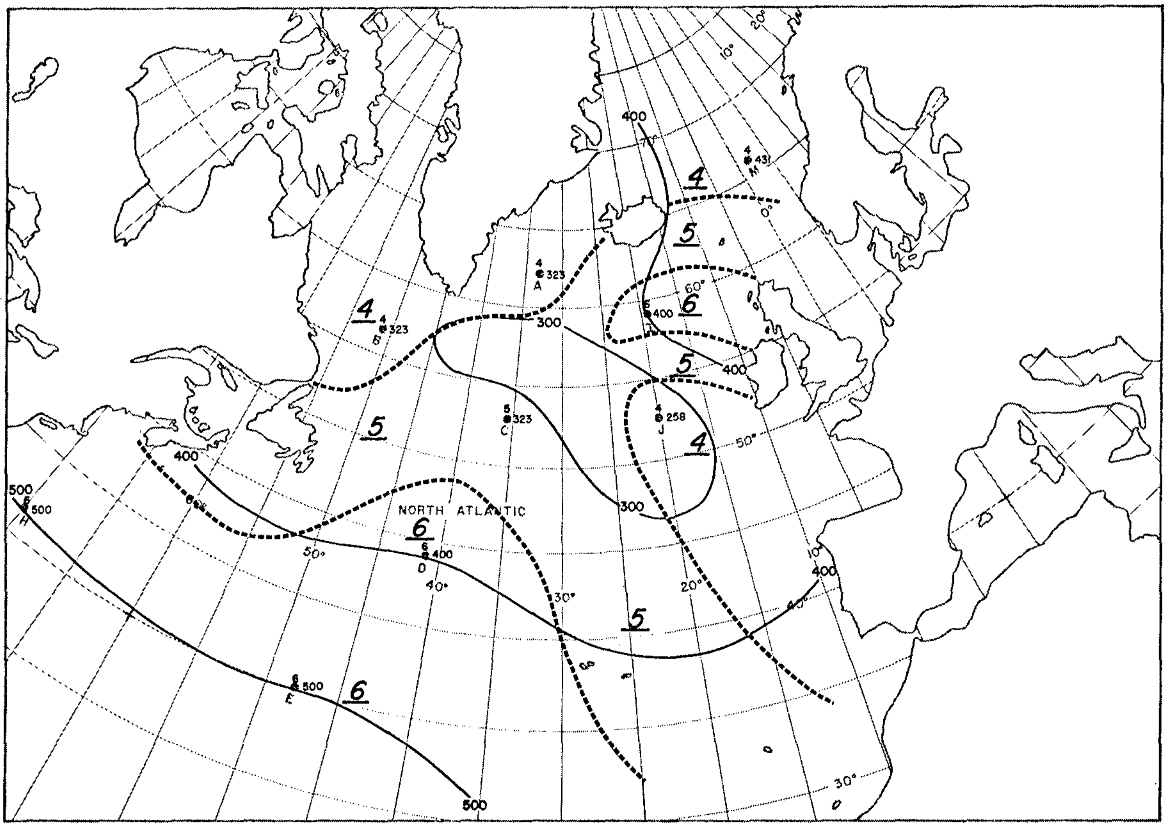



*Figure 2.13 Analyses of P and D Values: North Atlantic Ocean – Winter – Adverse Weather.*

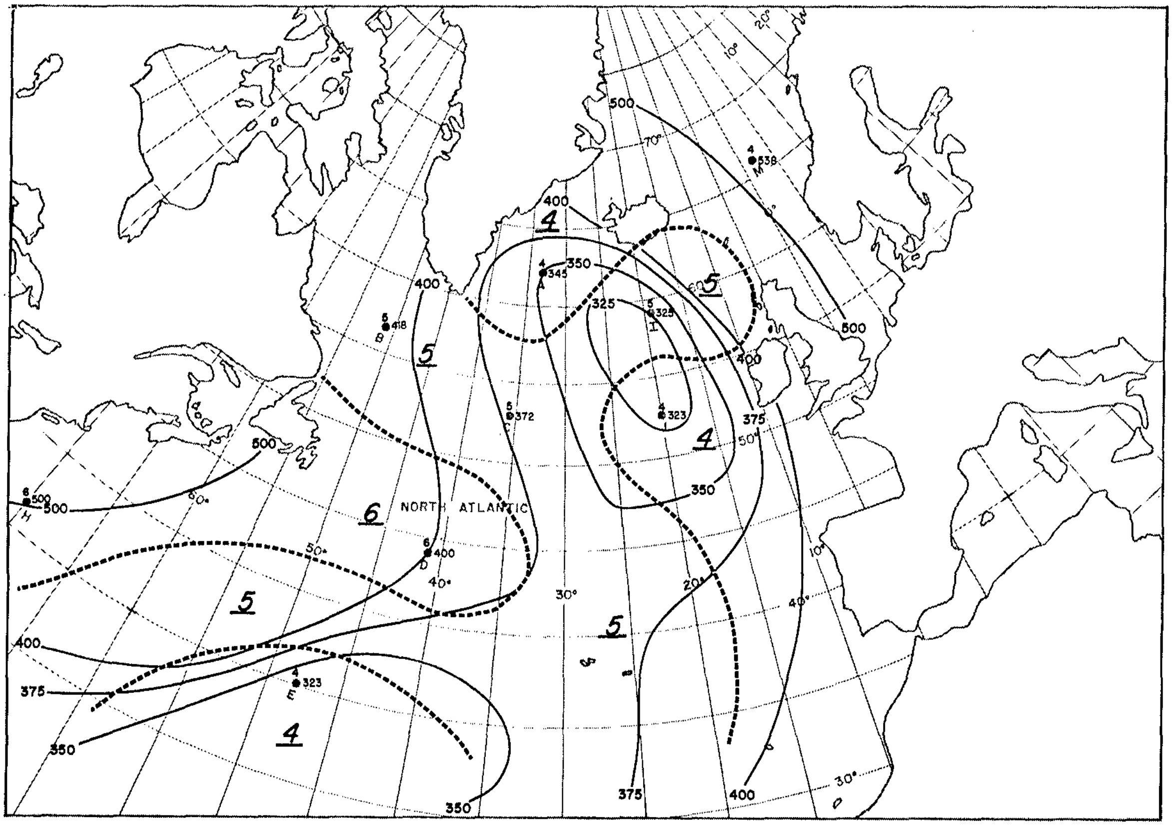



*Figure 2.14 Analyses of P and D Values: North Atlantic Ocean – Spring – Adverse Weather.*

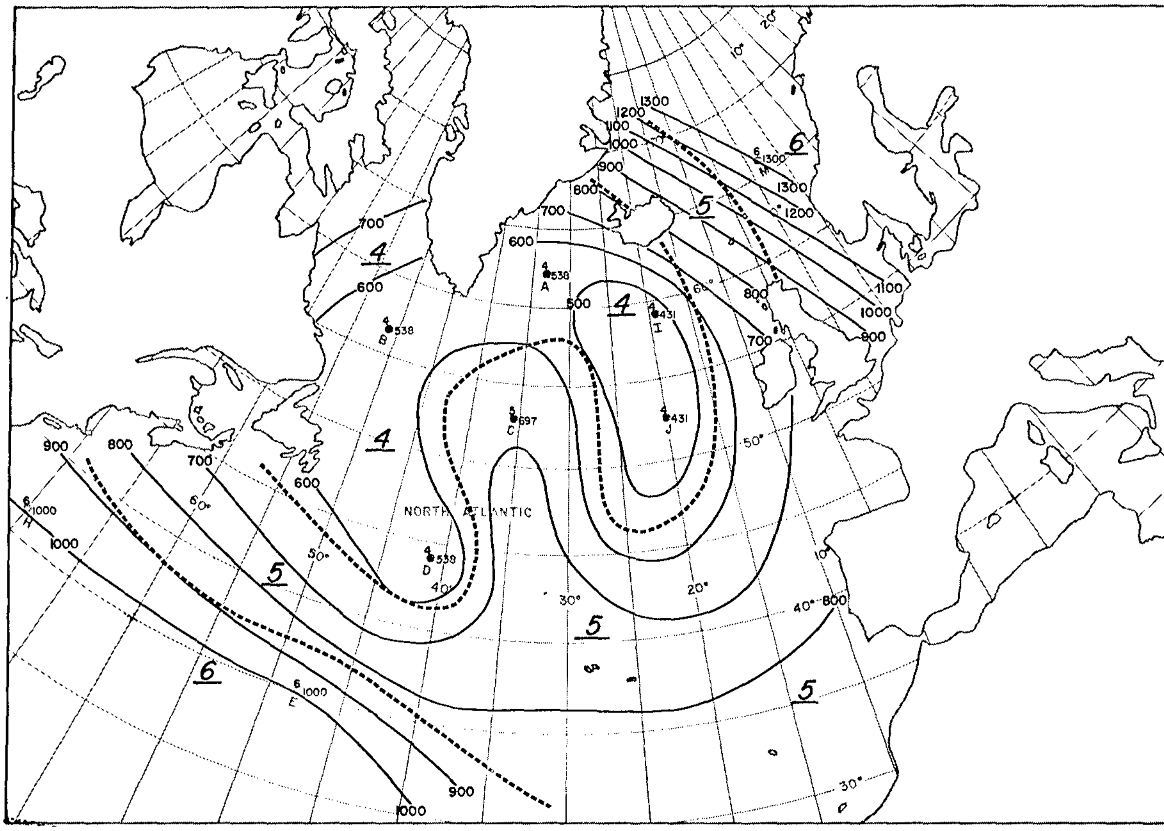



*Figure 2.15 Analyses of P and D Values: North Atlantic Ocean – Summer – Adverse Weather.*

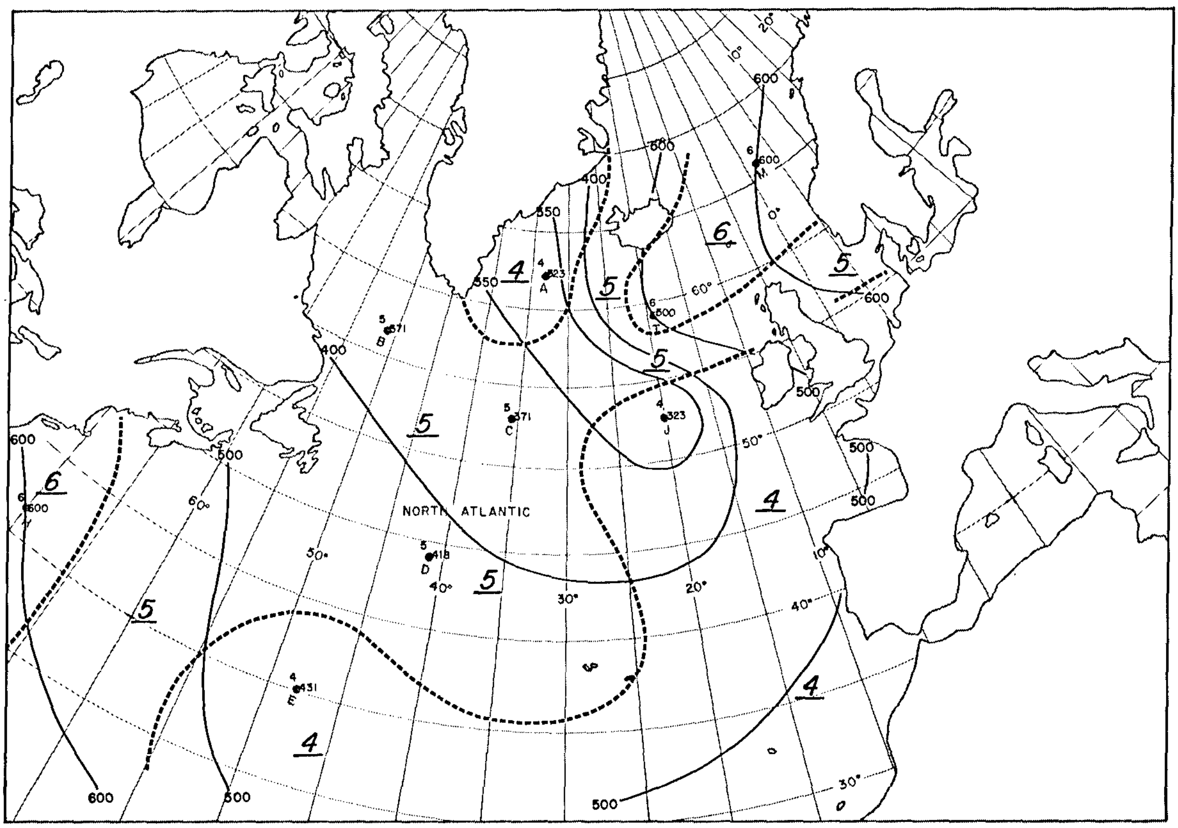



*Figure 2.16 Analyses of P and D Values: North Atlantic Ocean – Fall – Adverse Weather.*

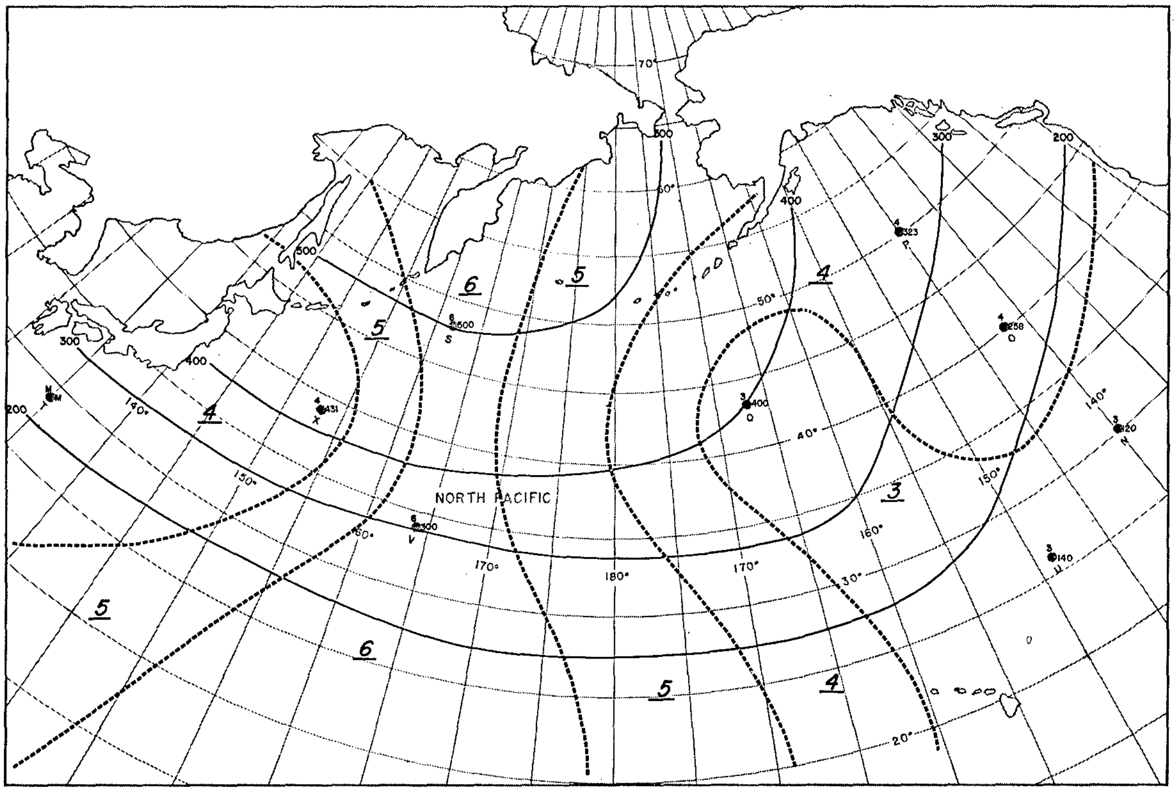



*Figure 2.17 Analyses of P and D Values: North Pacific Ocean – Winter – Favorable Weather.*

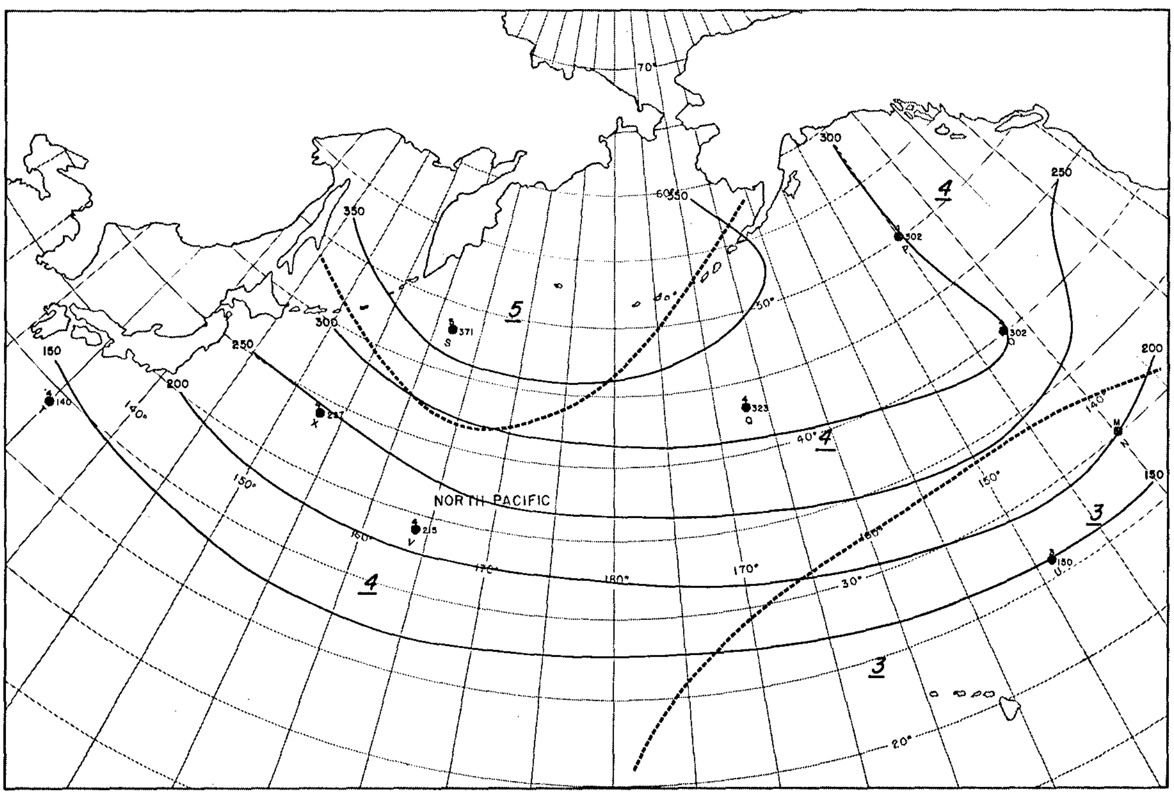



*Figure 2.18 Analyses of P and D Values: North Pacific Ocean – Spring – Favorable Weather.*

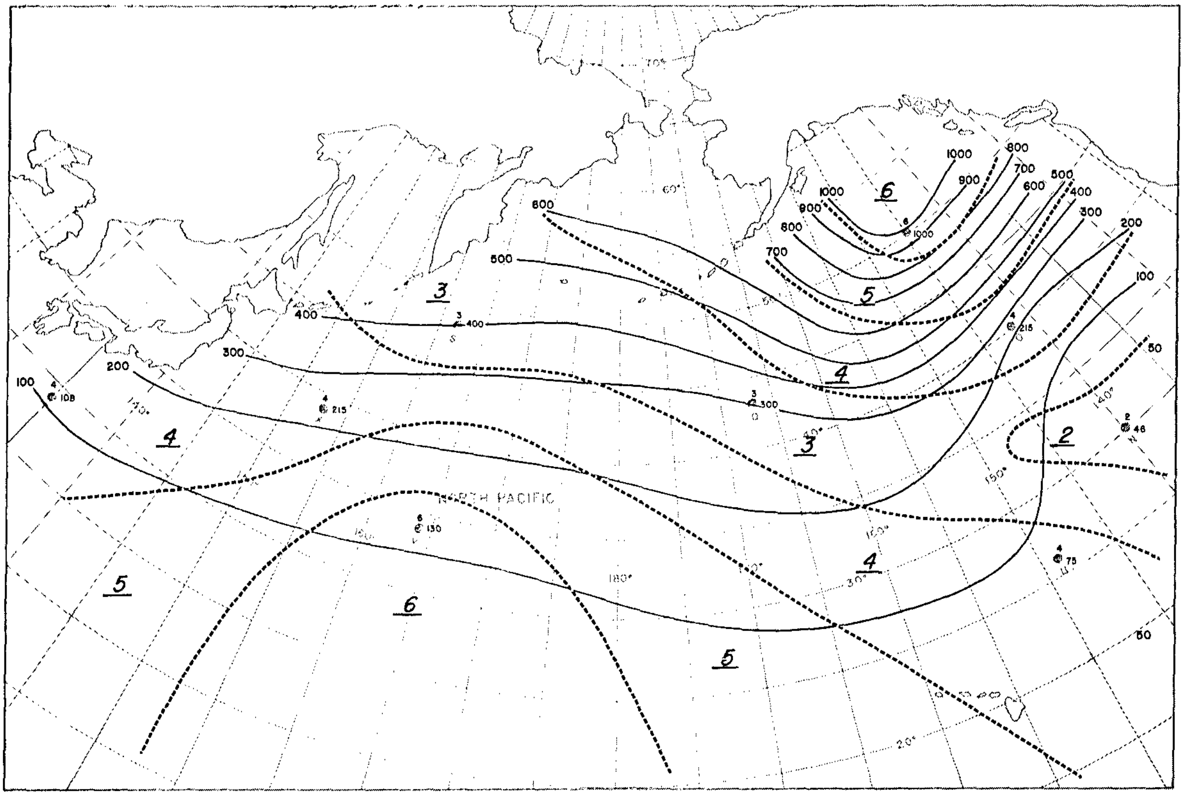



Figure 2.19 Analyses of P and D Values: North Pacific Ocean – Summer – Favorable Weather.

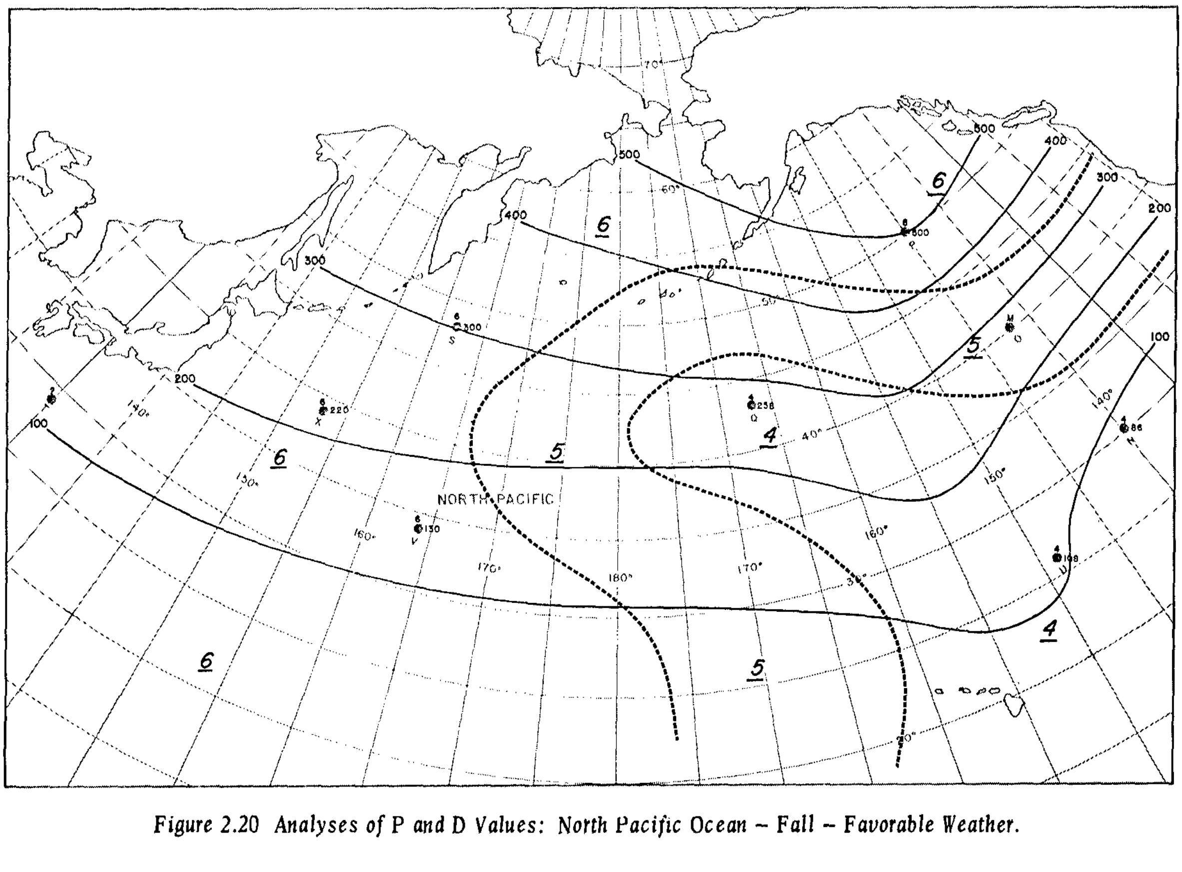



Figure 2.20 Analyses of P and D Values: North Pacific Ocean – Fall – Favorable Weather.

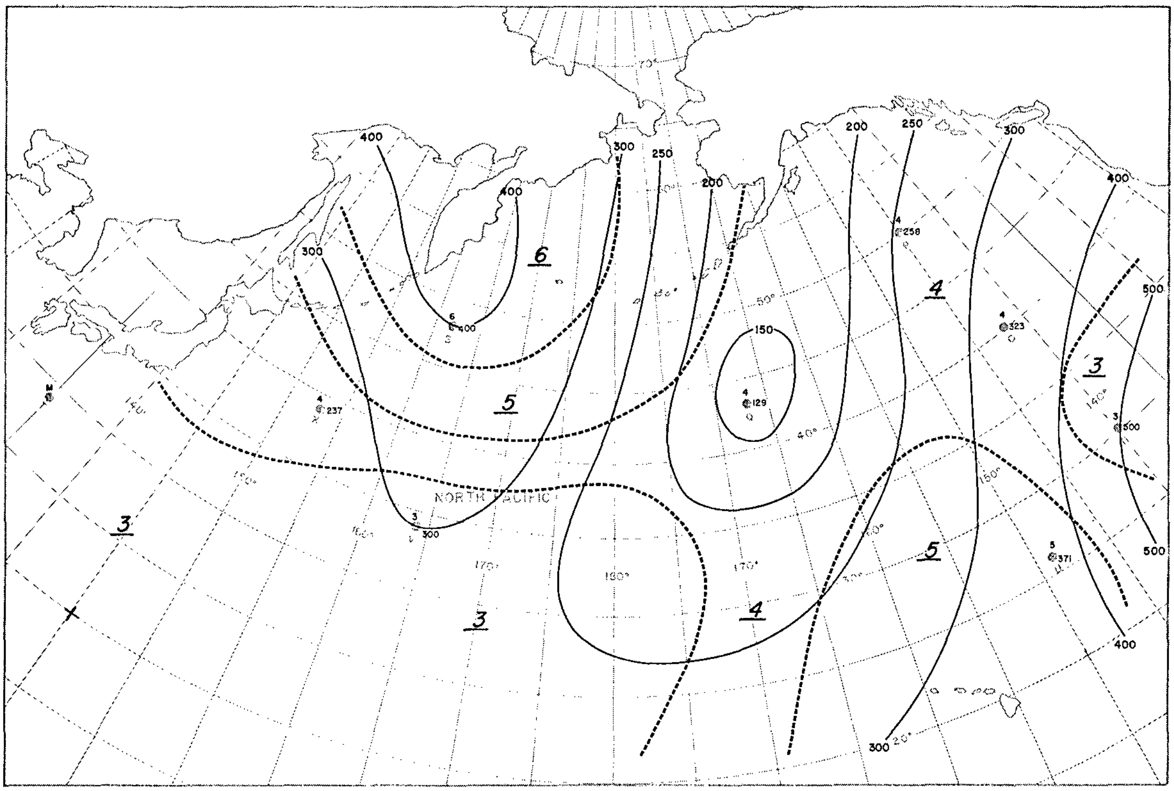



Figure 2.21 Analyses of P and D Values: North Pacific Ocean – Winter – Adverse Weather.

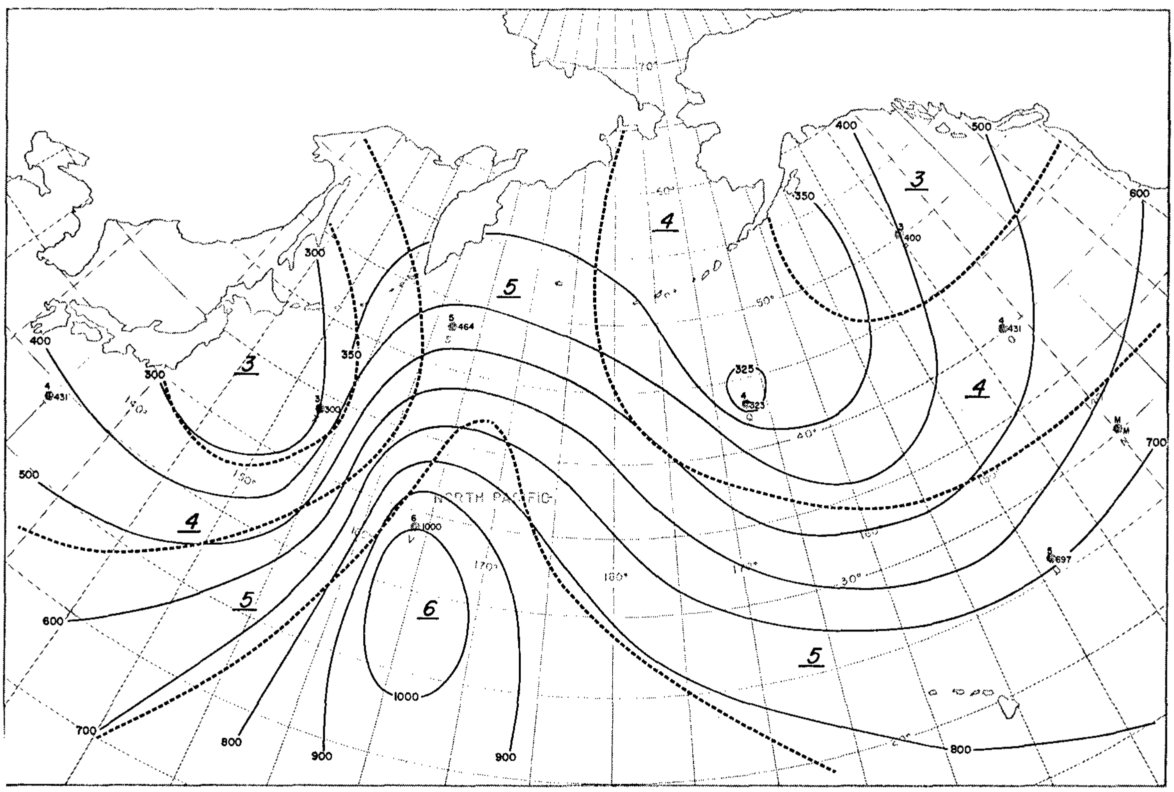



Figure 2.22 Analyses of P and D Values: North Pacific Ocean – Spring – Adverse Weather.

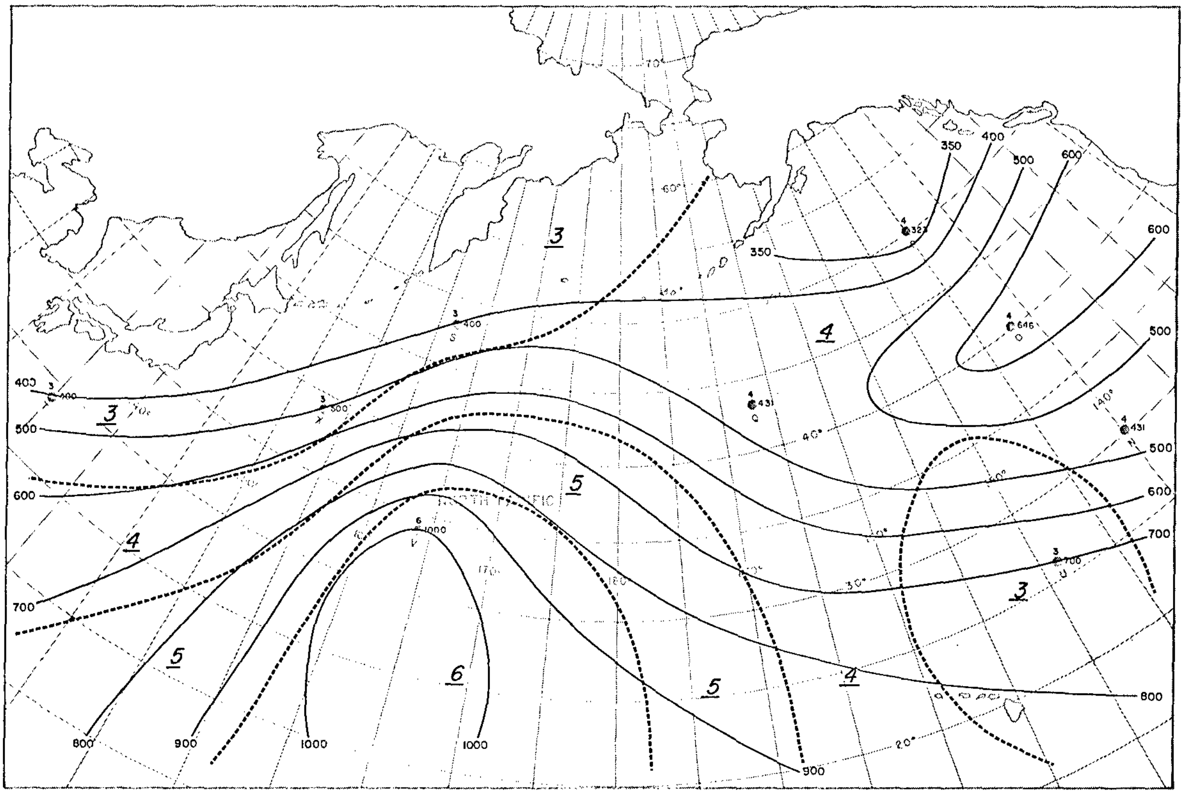



Figure 2.23 Analyses of P and D Values: North Pacific Ocean – Summer – Adverse Weather.

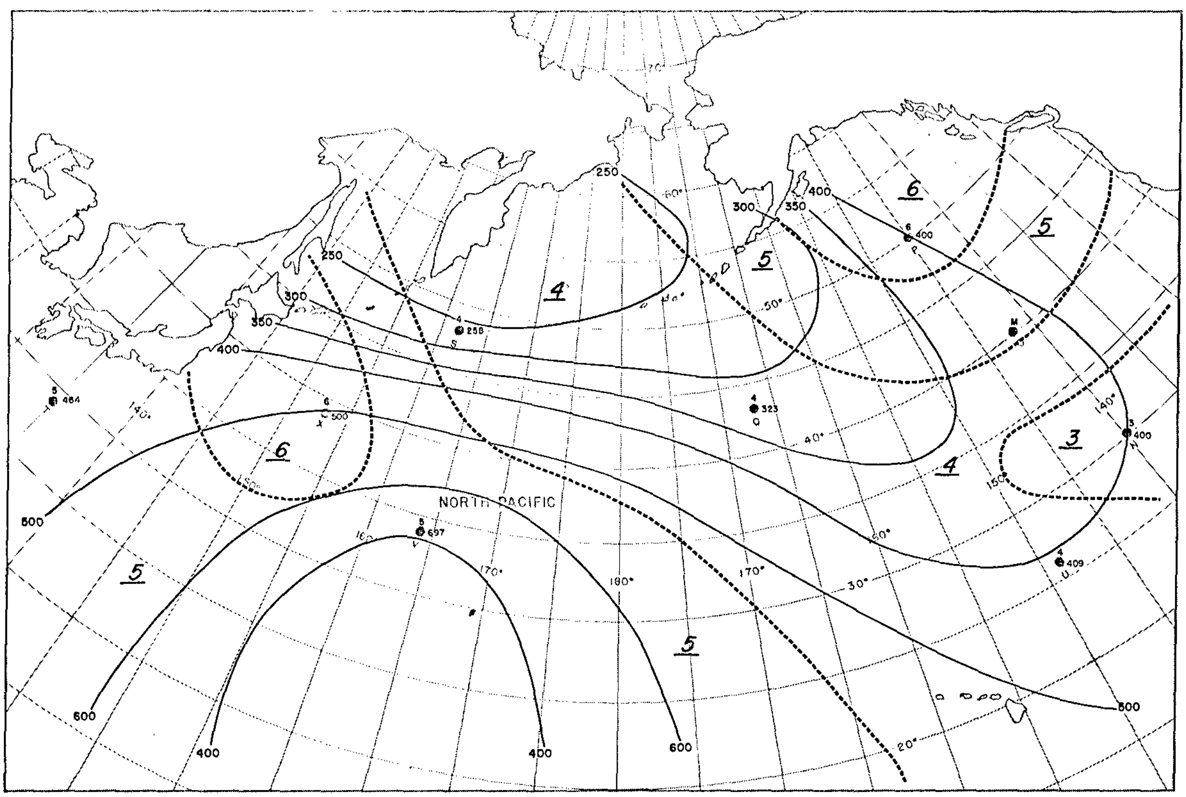



Figure 2.24 Analyses of P and D Values: North Pacific Ocean – Fall – Adverse Weather.

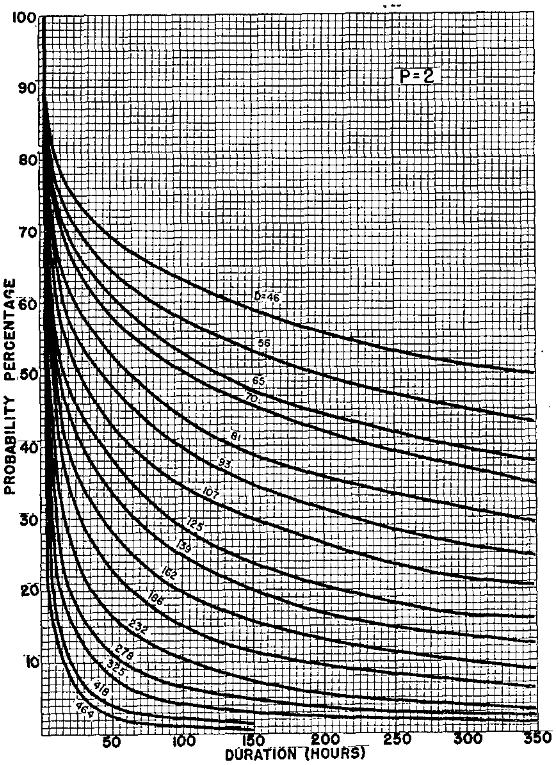



Figure 2.25 Type I Probability Duration D Curves (Generated): P Value of 2.

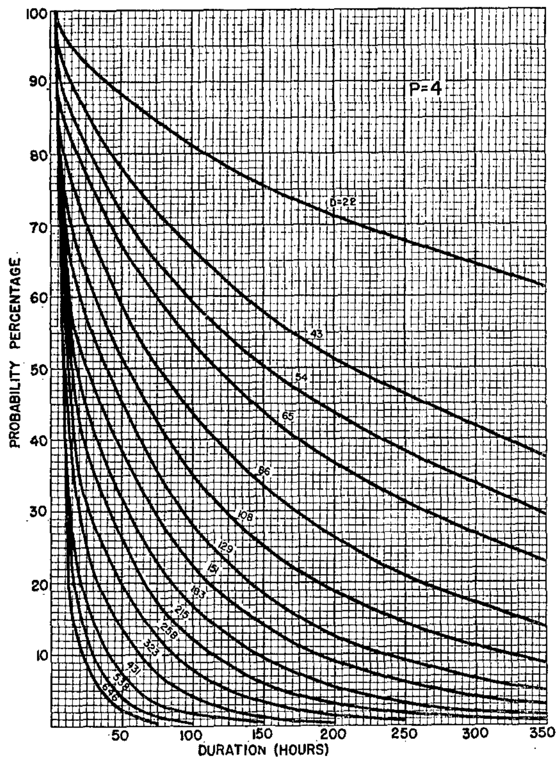



Figure 2.27 Type I Probability Duration D Curves (Generated): P Value of 4.

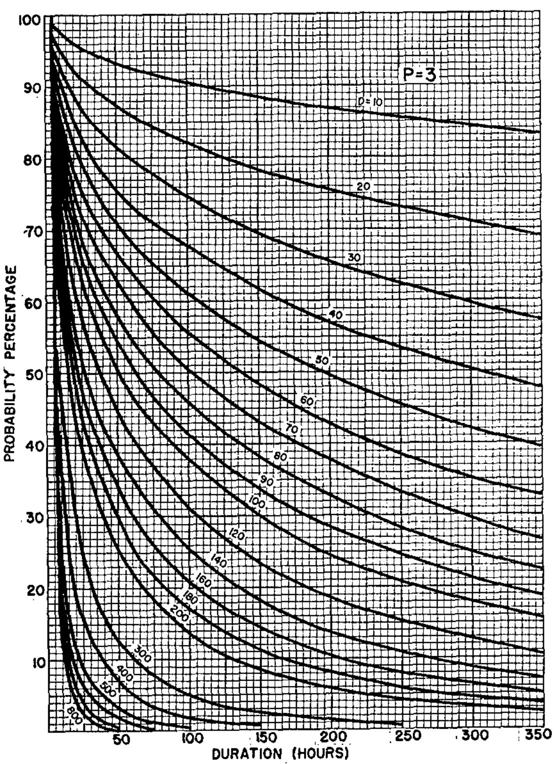



Figure 2.26 Type I Probability Duration D Curves (Generated): P Value of 3.

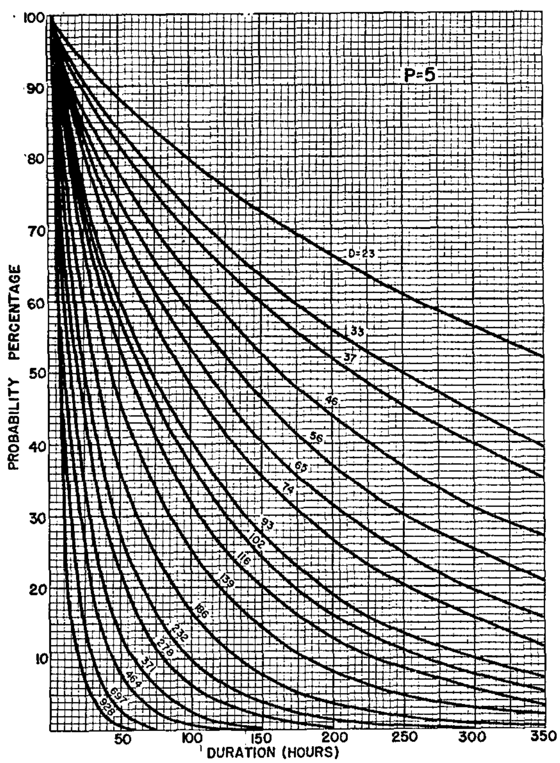
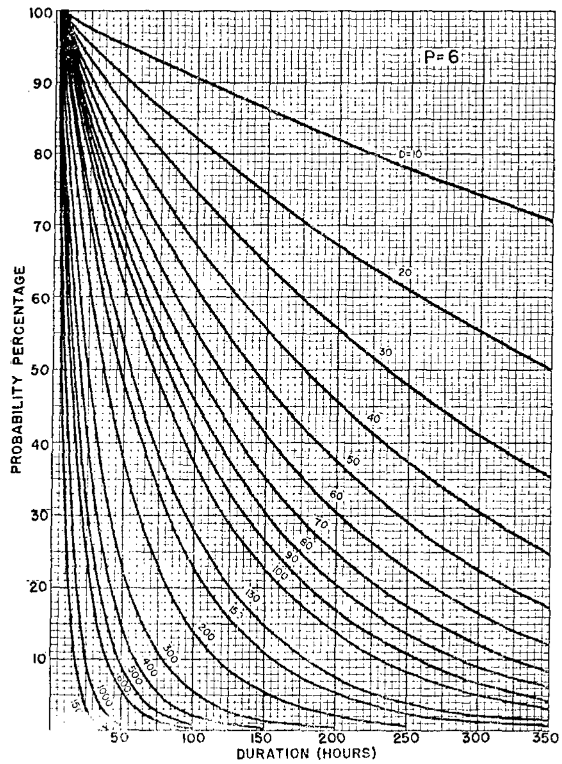



Figure 2.28 Type I Probability Duration D Curves (Generated): P Value of 5.




F[illegible]re 2.29 *Type I Probability Duration D Curves (Generated): P Value of 6.*

# 3. TYPE II PROBABILITY CURVES

## 3.1 Description and Interpretations

References [1] and [2] provide a complete seasonal collection of type II individual allowance probability curves for planning carrier task force operations near selected station vessel locations (listed in tables 1.1 and 1.2, chapter 1) in the North Atlantic and North Pacific Oceans. This chapter presents a full set of operational data presentations for estimating type II individual allowance probability curves.

The data were derived from values resulting when the existing type II probability curves, referred to above, were fitted empirically with curves generated with two mathematical parameters *I* and *A* (Individual-Allowance). The data are divided into two parts. The first part is made up of a special set of 40 maps. The second part is made up of a set of 8 curve families especially prepared for this publication. Section 3.2 presents examples of data application. Section 3.3 presents the entire set of maps and section 3.4 presents the complete collection of curve families. Virtually all of the original curves of 5 operation periods (3, 12, 24, 48, and 72 hours) were fitted with generated curves to an acceptable tolerance of error of 5 percent. Values were assigned to the *I* and *A* parameters described above, so that the values uniquely identify the type II curve fits. Figure 3.1 portrays a typical family of curves generated with many *A* values paired with a single *I* value of 2.

Note that many values of *A* , but only 8 *I* values (i.e., 2, 3, 4, 5, 6, 7, 8, and 9) were employed in fitting the real curves. The vertical axis is scaled in "Probability Percentage" from zero to 100 percent and the horizontal axis in "Individual Allowance (Hours)" from zero to 420 hours. This format is the same one used in the original graphs (fig. 1.2). Generated curves, like their real counterparts, slope asymptotically upward from left to right. These generated curves, relating lengths of individual allowance to probability percentage, may be applied for any operation period. Use that part of the curve lying to the right of the vertical line that coincides with the value for the operation period being considered. The 5 operation periods are indicated on the graph with 5 dashed vertical lines extending upward from the abscissa. See section 3.2 for detailed application examples. The reader should not confuse the labeling of generated type II curves with *A* values (fig. 3.1) and the labling of the original type II curves with the 5 operation periods (fig. 1.2). Note in figure 3.1, that curves of high *A* values are located near the top of the graph and curves of low *A* values are located near the bottom. Therefore, such generated curves of relatively low *A* values yield relatively low probabilities for given individual allowances. Conversely, curves of relatively high *A* values yield relatively high probabilities. *A* is considered the primary parameter and *I* the secondary parameter in fitting type II curves.

The first part of the operational data is presented in section 3.3 in the form of seasonal maps depicting analyses of the *I* and *A* values used to fit the original individual allowance probability curves. Figures 3.2 and 3.3 provide two typical examples of such analyses for an operation of two different operation periods. The *I* and *A* values were plotted on surface maps in accord with the model given in figure 3.4 and analyzed.

The fields of *I* and *A* in figures 3.2 and 3.3 were separately analyzed. A field of primary parameter is a continuous scalar field like that of pressure on a surface map or of temperature on an upper-level constant-pressure map. The fields of parameter *A* were, therefore, analyzed for significant values with isopleths of thin solid lines. The reader may extract *A* values for a given area, from a map, by extrapolating linearly between isopleths. A field of secondary parameter *I* is not a continuous scalar field. The *I* field may, however, be separated into homogeneous areas of equal *I* values (by the heavy dashed lines on the maps). Each I area in the 2 figures was assigned a value of 4, 5, and 6, depending on the plotted data. Other maps in the series contain values of 2, 3, 4, 5, 6, 7, 8, and 9, depending on individual map data. All *I* area values are clearly labeled with large slanted numbers. *I* values may be extracted from a map by assuming that all locations lying in a given area receive the same *I* value (i.e., the value assigned to the area). A location on a map that lies on a heavy dashed line separating two adjacent *I* areas, however, receives the *I* value of the lower valued area. For example, a point on the boundary between an *I* area of 4 and an *I* of 5 would receive a value of 4.

Maps, such as those shown in figures 3.3 and 3.4 and presented in section 3.4, may be interpreted meteorologically. Map areas delineated by maximum isopleth values of *A* represent re-

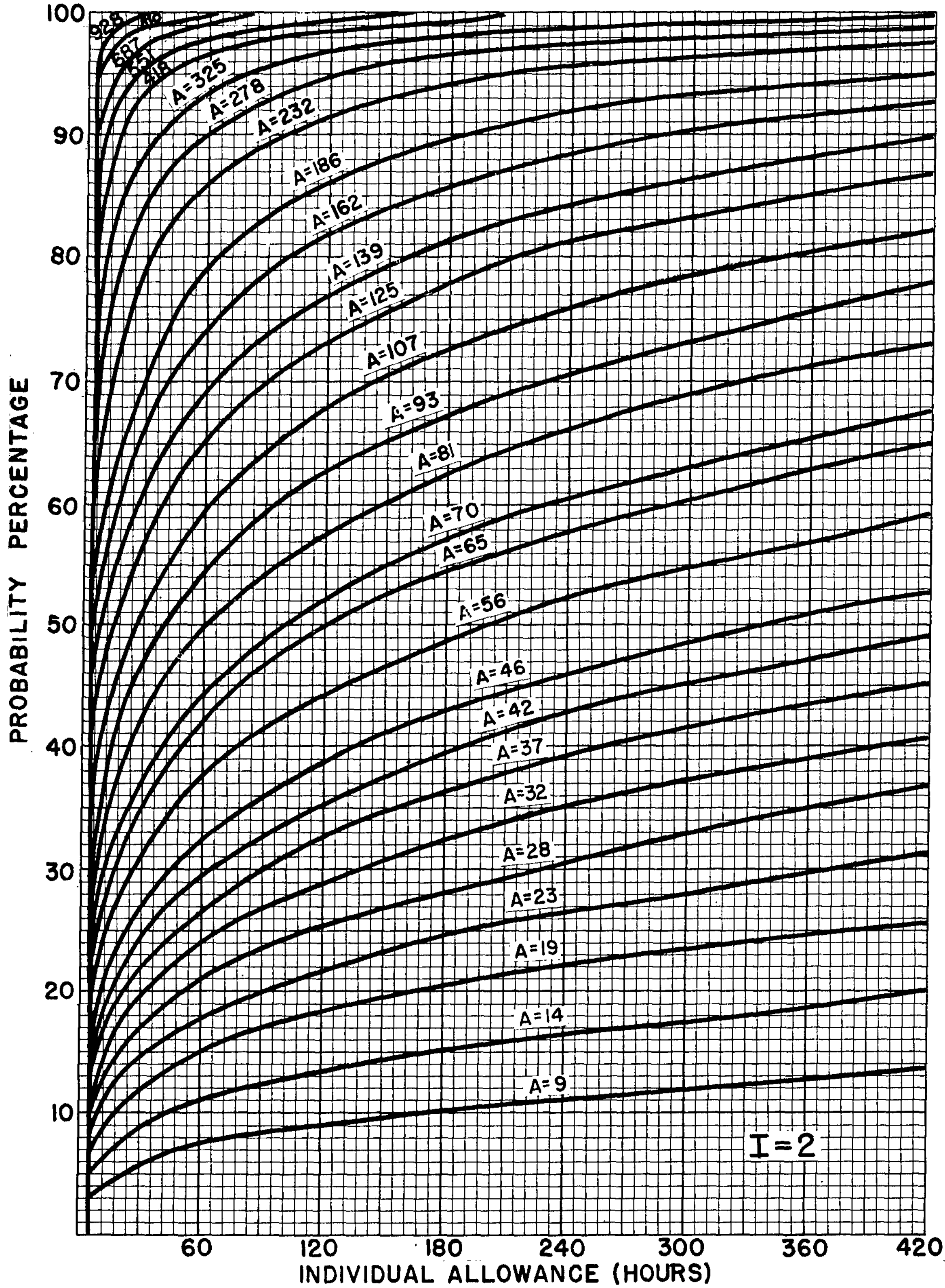



*Figure 3.1 Type II Individual Allowance A Curves (Generated): I Value of 2.*

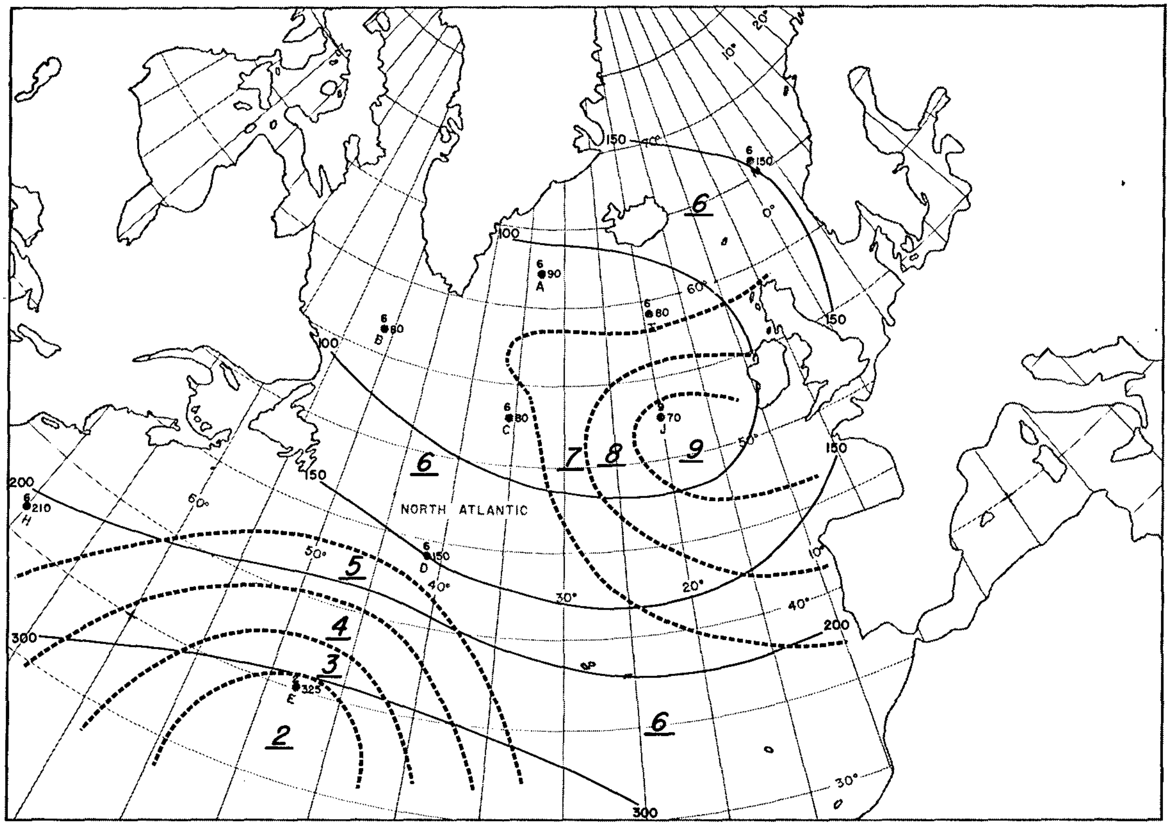



*Figure 3.2 Analyses of I and A Values: North Atlantic Ocean – Summer – 48-Hour Operation Period.*

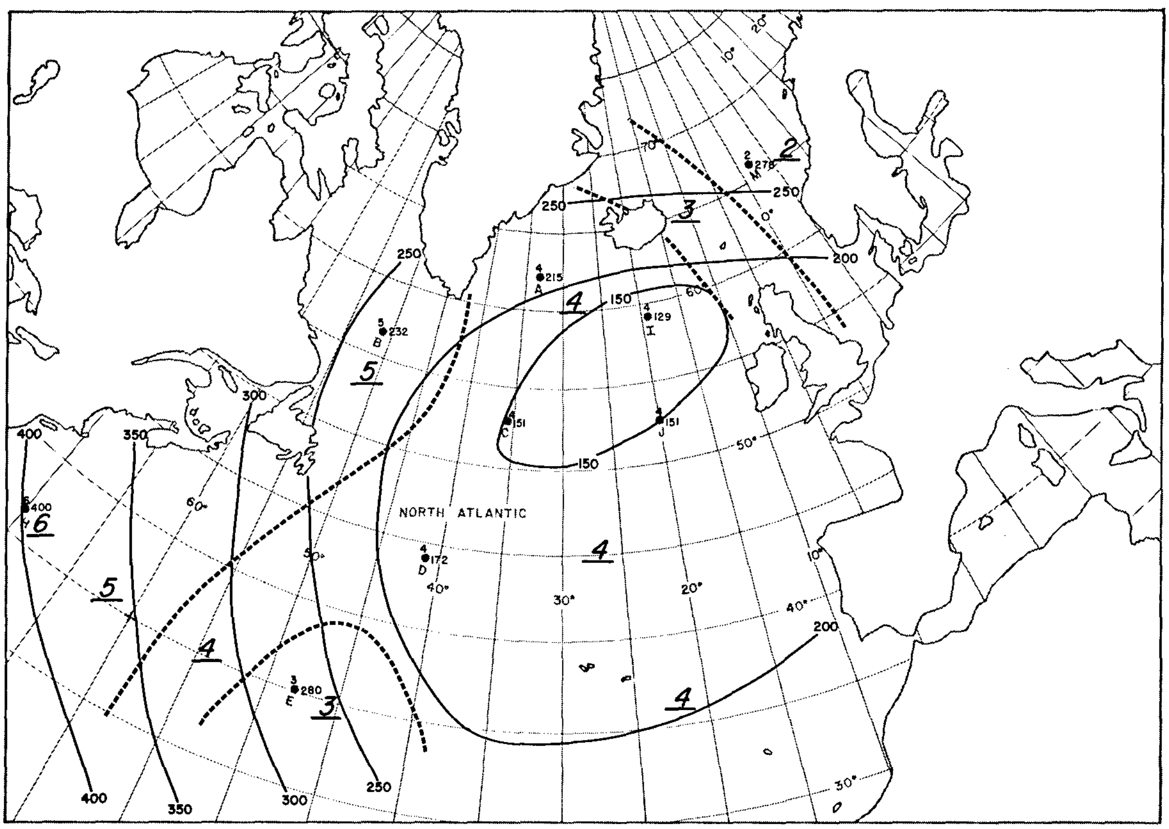



*Figure 3.3 Analyses of I and A Values: North Atlantic Ocean – Winter – 12-Hour Operation Period.*

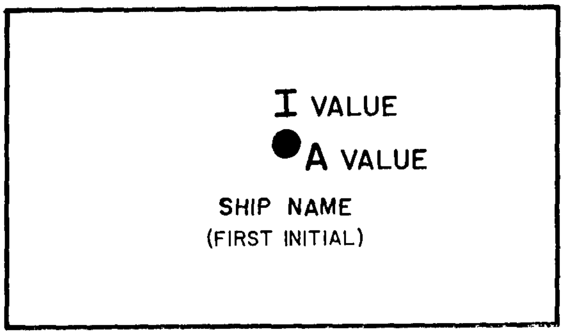



*Figure 3.4 Plotting Model – I and A Values.*

gions of relatively high individual allowance probabilities, subject to the modifying effect of secondary parameter $I$. Likewise, areas delineated by minimum values of $A$ represent regions of relatively low individual allowance probabilities, also subject to the modifying effect of $I$.

When the user estimates a type II curve, the $A$ value establishes the primary estimate and the $I$ value refines the primary estimate to obtain a final composite curve. A planner may estimate a type II individual allowance probability curve for a selected area by:

(1) Extracting seasonal values of parameters $I$ and $A$, from an appropriate map in section 3.3, as discussed above.

(2) Interpolating a curve that matches the extracted values from an appropriate curve family out of the set in section 3.4.

Section 3.2 comprehensively explains, with examples, the application of curve estimates set forth in this section.

## 3.2 Applications

Typical problems and their solutions are offered as a reference in estimating type II individual allowance probability curves and in applying such estimates in operational planning. The techniques involved refer to any specified North Atlantic Ocean or North Pacific Ocean location and to given lengths of individual allowance for any climatic season (as defined in chapter 1, paragraph 1.4). Application examples are presented in two parts. The first part is concerned only with estimation of the curves, and the second, with application of these curve estimates in operational planning.

### 3.2.1 *Estimating Type II Probability Curves*

Example 1: Individual allowance probability curve of a given length of operation period for a given specified area.

Problem 1:

Estimate a type II probable individual allowance curve for planning an operation requiring 12 hours of uninterrupted favorable weather at 45.0° N. latitude and 25.0° W. longitude in the North Atlantic during winter.

Solution:

Consult the North Atlantic winter map of analyzed $I$ and $A$ values for a 12-hour operation period (fig. 3.3) and focus attention on the specified location. Note that the locality falls within a homogeneous $I$ area, value of 4, and lies between the 150 $A$ isopleth and the 200 isopleth. Interpolate between the two isopleths to obtain an $A$ value and extract directly the $I$ value of the associated $I$ area. The reader should obtain an $I$ value of 4 and an $A$ value of 167.

Consult the set of curves corresponding to an $I$ value of 4 (fig. 3.5). Note that the curve for an $A$ value of 167 should lie on the curve somewhere between the curves for $A$ values of 151 and 183. The curve desired may be sketched in pencil on the printed set after interpolating logarithmically between the two given $A$ curves. The part of the estimated curve that applies to a 12-hour operation period lies to the right of the dashed vertical 12-hour individual allowance line.

Problem 2:

Estimate a type II individual allowance probability curve for a 24-hour operation period for 43.9° N. latitude and 45.8° W. longitude in the North Atlantic during summer.

Solution:

Seek out the North Atlantic summer map of analyzed $I$ and $A$ values for a 24-hour

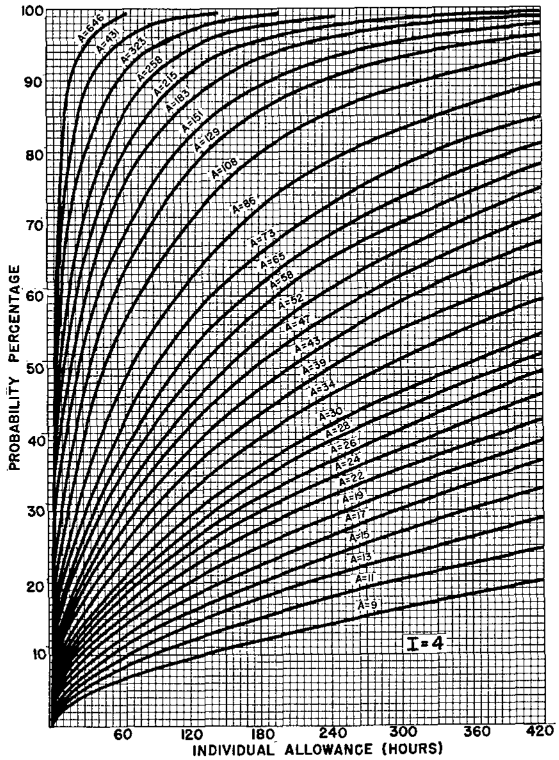



*Figure 3.5 Type II Individual Allowance A Curves (Generated): I Value of 4.*

operation period (fig. 3.6) and look at the location stated. This locality falls on the boundary separating two adjacent *I* areas which are valued 5 and 6. Therefore, select the lower *I* value (i.e., 5) for the location being considered. The locality also lies on the 400 value *A* isopleth, so select an *A* value of 400.

Then investigate the family of curves for an *I* value of 5 (fig. 3.7). Notice that the curve for an *A* value of 400 should lie in this set somewhere between the curves for *A* values of 278 and 464. The curve desired may be indicated by pencil on the printed set after interpolating logarithmically between the *A* curves (see fig. 3.7). The part of the curve estimate that applies to a 24-hour operation lies to the right of the dashed vertical 24-hour individual allowance line.

Problem 3:

Make an estimate of a type II probability curve for a 48-hour operation period for an area located at 41° N. latitude and 155° W. longitude in the North Pacific during spring.

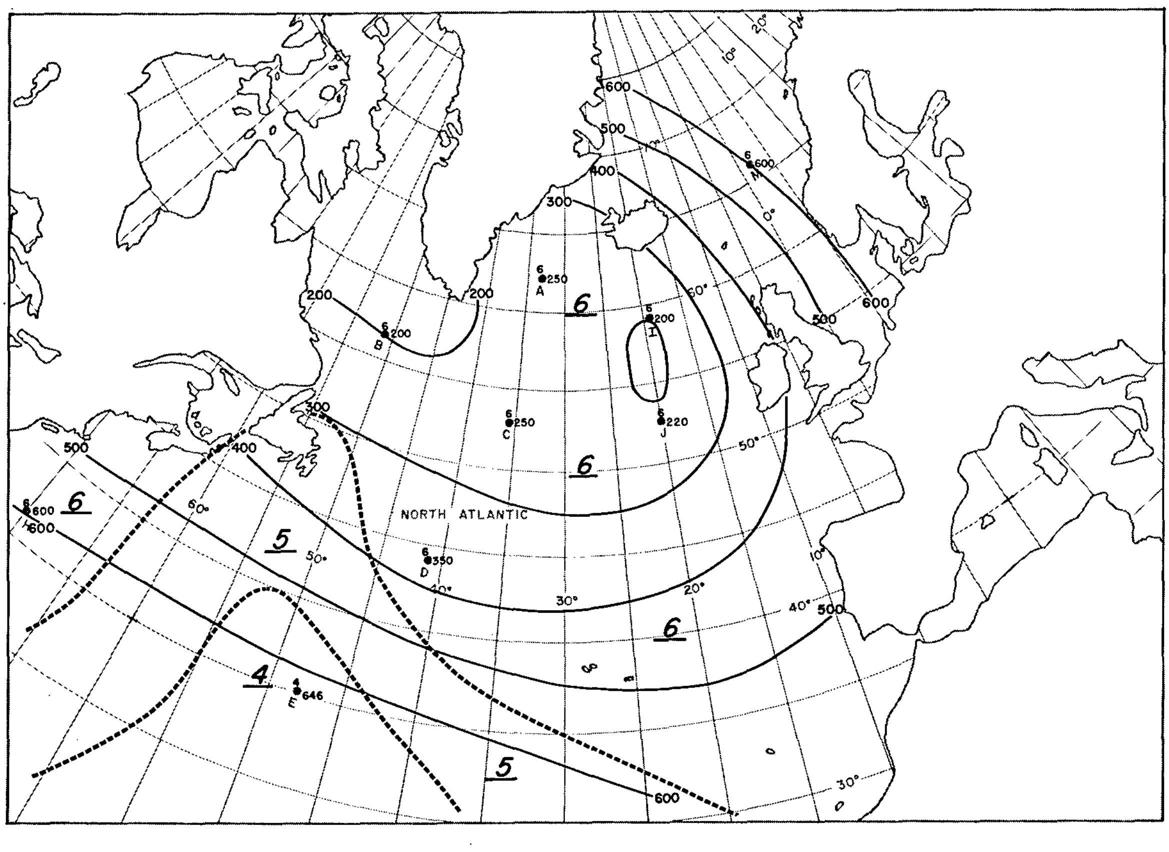



*Figure 3.6 Analyses of I and A Values: North Atlantic Ocean – Summer – 24-Hour Operation Period.*

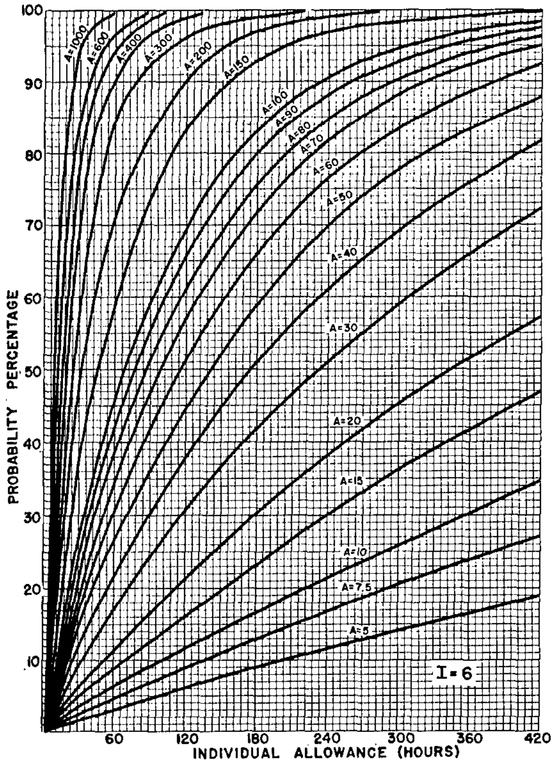



*Figure 3.7 Type II Individual Allowance A Curves (Generated): I Value of 6.*

Solution:

As in problems 1 and 2 above consult the North Pacific spring map of analyzed $I$ and $A$ values for a 48-hour operation period (fig. 3.8) and examine the location specified. The location falls in an $I$ area value of 5. It also lies between the 50 $A$ isopleth and the 100 isopleth. By interpolating between these two isopleths and extracting the value of the associated I area, the reader should obtain an $I$ value of 5 and an $A$ value of 74 for the location.

To estimate the wanted type II curve consult the set of curves for an $I$ value of 5 (fig. 3.7). Note that the curve for $A$ equals 74 in the set (from fig. 3.7) corresponds to the $A$ value of 74 obtained from figure 3.8. The part of this curve that is applicable to a 48-hour operation period lies to the right of the dashed vertical 48-hour individual allowance line.

Problem 4:

Obtain an estimate of a type II probability curve for a 72-hour operation period for an area at 32.2° N. latitude and 172.8° E. longitude in the North Pacific during fall.

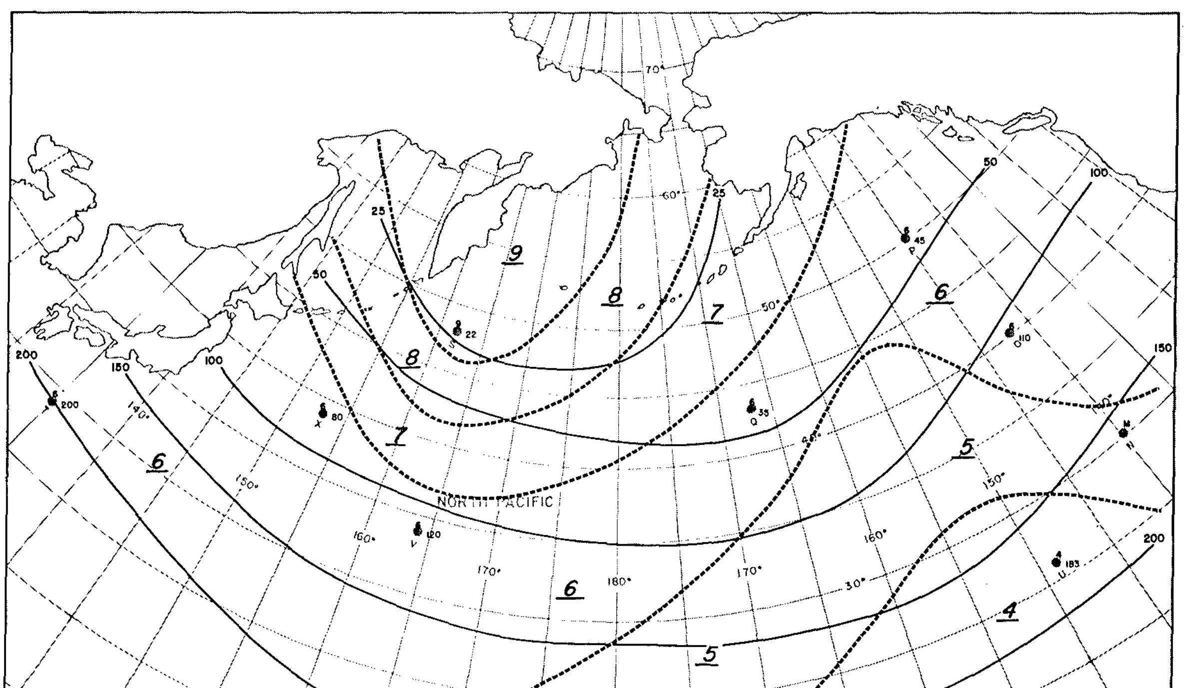



*Figure 3.8 Analyses of I and A Values: North Pacific Ocean – Spring – 48-Hour Operation Period.*

Solution:

Look up the North Pacific fall map of analyzed values for the 72-hour operation period (fig. 3.9) and examine 32.3° N. latitude and 172.8° E. longitude. The area lies on the boundary separating two adjacent *I* areas which are valued at 6 and 7. Thus, select the lower *I* value of 6 for the location. This location also falls directly on the 100 value *A* isopleth so choose an *A* value of 100.

Consult the set of curves for an *I* value of 6 (fig. 3.10). The curve for an *A* value of 100 is the curve in the set that corresponds to the *A* value of 100 obtained from figure 3.9. That part of this curve applying to a 72-hour operation period lies to the right of the dashed vertical 72-hour individual allowance line.

### 3.2.2 Applying Type II Curve Estimates

Example 1: Find the length of the waiting period necessary in order to be able to operate for a specified duration when adverse weather is present on arrival at a particular location.

Problem 1:

Given that adverse weather is encountered when a vessel arrives in an area located at 45° N. latitude and 25° W. longitude (North Atlantic) during winter, determine the probability that the maximum waiting period anticipated (see paragraph 1.4) will be no longer than 50 hours before the weather turns favorable and remains so long enough to complete an operation of 12-hours.

Solution:

Estimate the desired type II individual allowance probability curve for a 12-hour operation period (problem 1, example 1, section 3.2.1, above). Concentrate upon that part of the curve lying to the right of the dashed vertical 12-hour individual allowance line. Read the ordinate value corresponding to the intersection of the estimated curve and the 62 hour (i.e., 50 plus 12) individual allowance line. The probability required is 68 percent that a 12-hour length of favorable operating weather will occur sometime within the 62 hours allowable time on station (in-

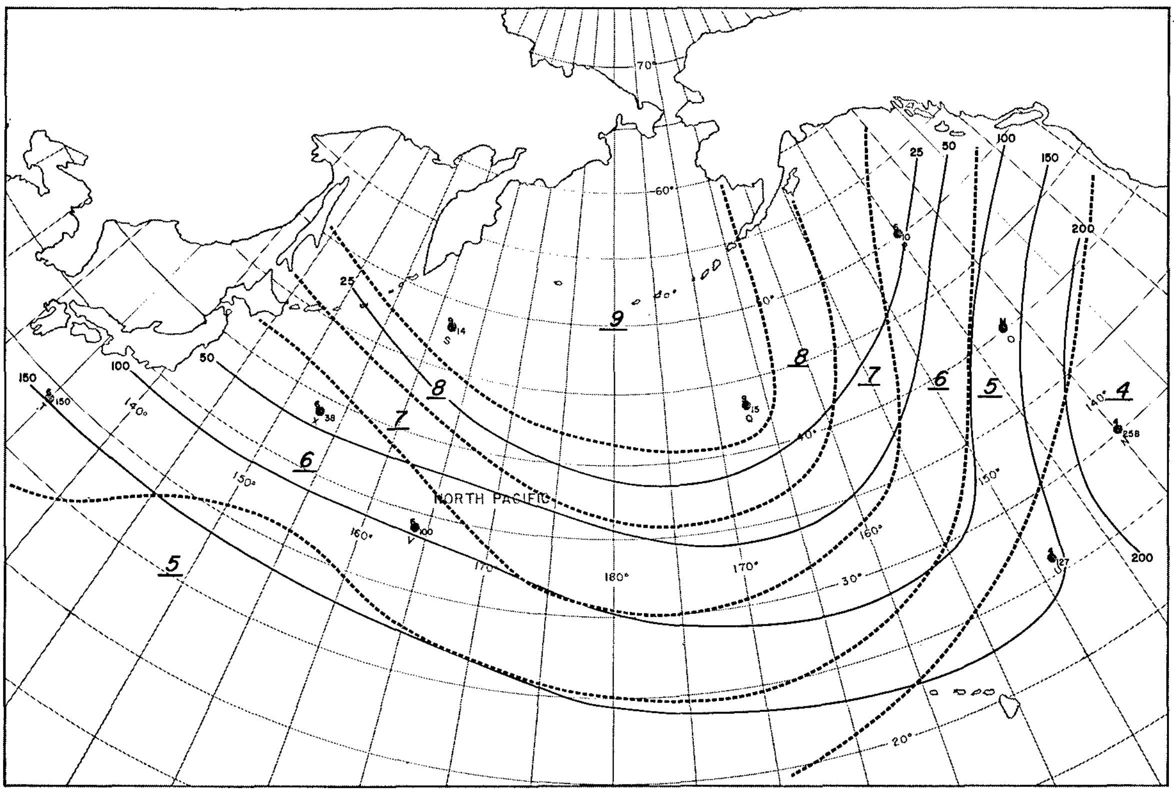



*Figure 3.9 Analyses of I and A Values: North Pacific Ocean – Fall – 72-Hour Operation Period.*

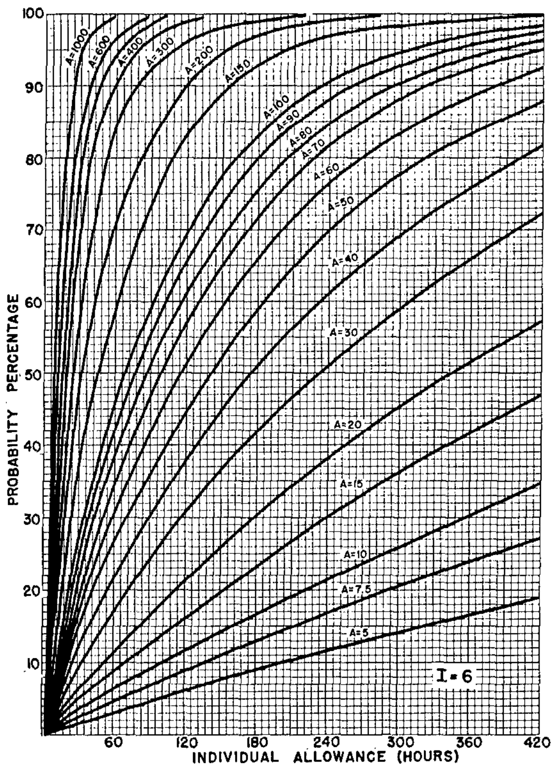



*Figure 3.10 Type II Individual Allowance A Curves (Generated): I Value of 6.*

dividual allowance).

Problem 2:

A planned operation in the area at 43.9° N. latitude and 45.8° W. longitude in the North Atlantic during summer (see problem 2, example 1, above) specifies that a carrier arrive in the area under adverse weather as a cover, operate aircraft 24 hours, and depart. The ship is assumed able to reach the area with adverse weather conditions, according to a current forecast. Other planning considerations dictate that a probability less than 50 percent of obtaining 24 hours of uninterrupted weather within 84 hours allowable time on station will curtail planning and cancel the operation. Will planning proceed under these conditions?

Solution:

Obtain an estimate of the type II curve desired for a 24-hour operation period (problem 2, example 1, above) and examine the part of the curve lying to the right of the dashed vertical 24-hour individual allowance line. Read the ordinate value corresponding to the intersection of the estimated curve and the 84 hour (60 plus 24) individual allowance line. The probability extracted is 96 percent. Since 96 percent exceeds 50 percent planning will continue.

Example 2: Find the probability of favorable weather persisting for a specified period, providing favorable weather exists upon arrival at a specific location.

Problem 1:

Favorable weather exists upon arrival at 41° N. latitude and 155° W. longitude in the North Pacific during spring (see problem 3, example 1, above). The time that it became favorable is unknown. Ascertain the probability of obtaining uninterrupted favorable weather for the subsequent 48 hours, to initiate immediately and successfully complete a task force operation.

Solution:

Estimate the curve desired (problem 1, example 1, section 3.2, above). Extract the ordinate value corresponding to the intersection of the estimated curve and the dashed vertical 48-hour individual allowance line. The probability obtained is equal to 33 percent.

### 3.3 Type II Curve Map Collection

This section presents 40 seasonal maps of analyzed I and A values, which include operation periods of 3-, 12-, 24-, 48-, and 72-hours. These maps are shown as figures 3.11 through 3.30 for the North Atlantic Ocean and figures 3.31 through 3.50 for the North Pacific Ocean.

### 3.4 Individual Allowance Probability Curve Collection

This section presents 8 sets of generated curve families for given I and A values. These curves are shown in figures 3.51 through 3.58.

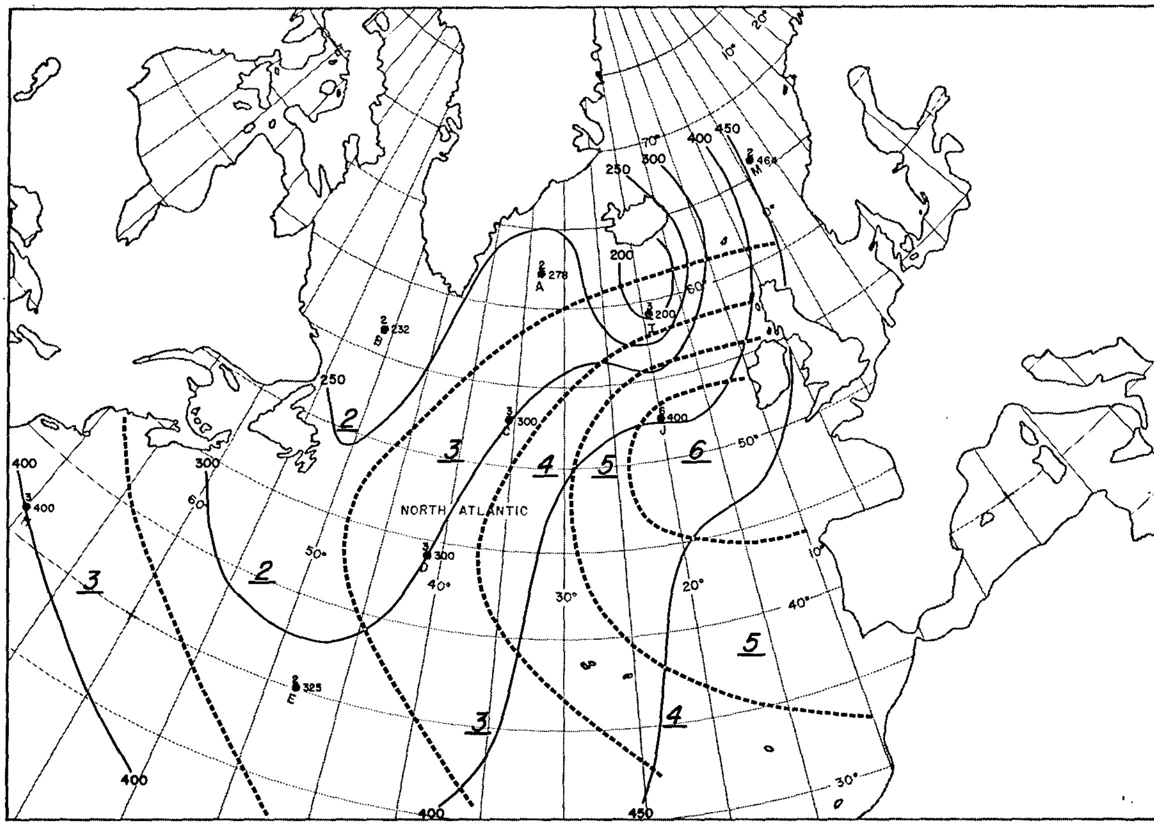



*Figure 3.11 Analyses of I and A Values: North Atlantic Ocean – Winter – 3-Hour Operation Period.*

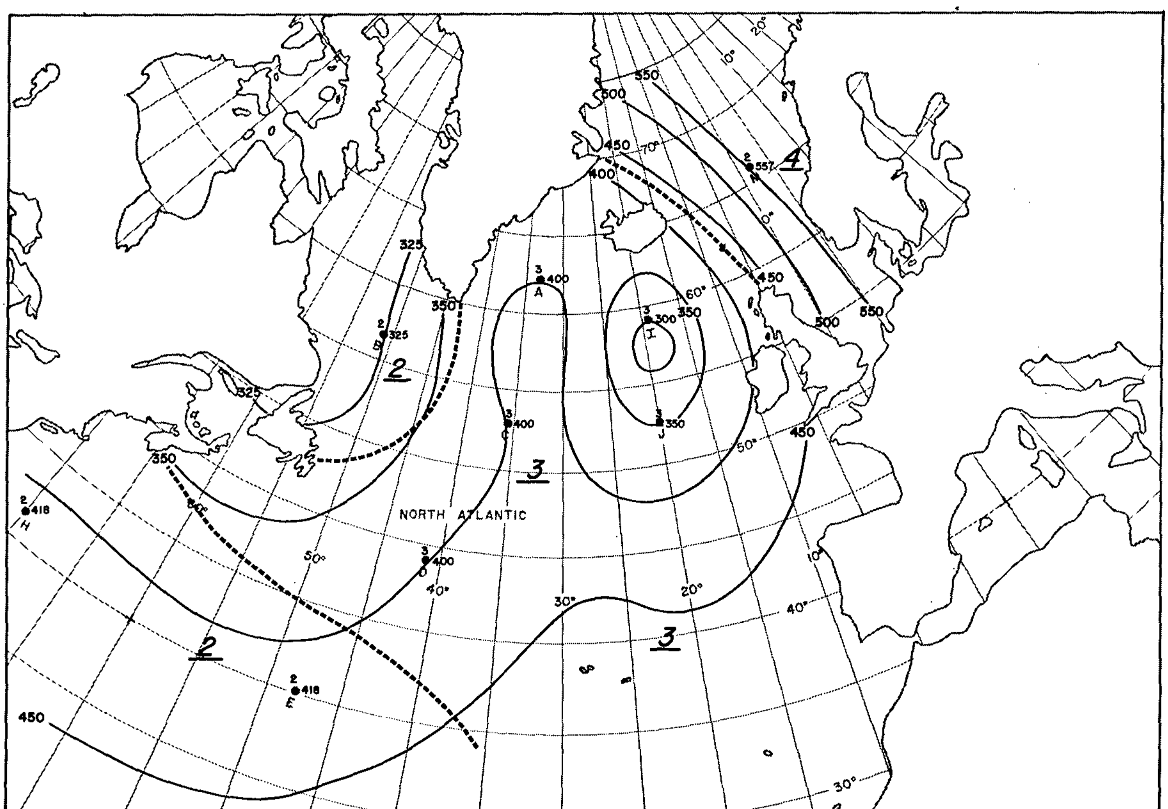



*Figure 3.12 Analyses of I and A Values: North Atlantic Ocean – Spring – 3-Hour Operation Period.*

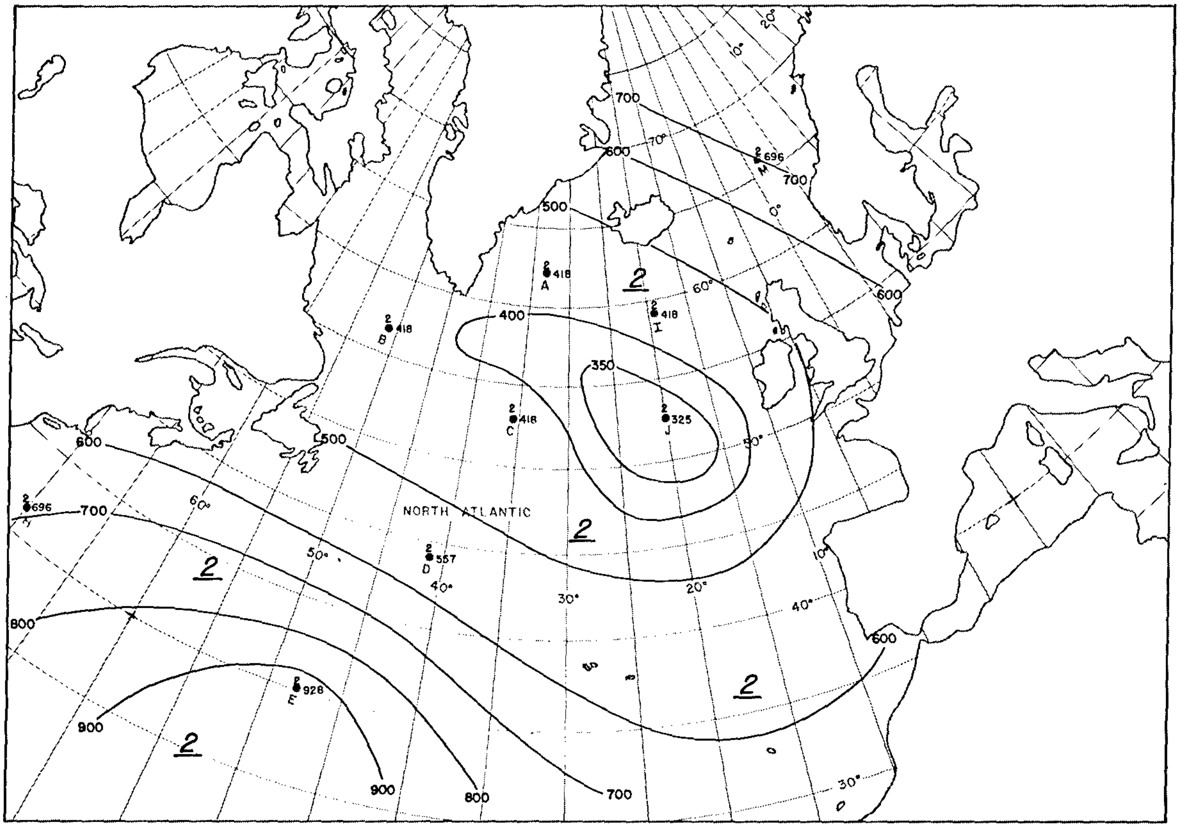



Figure 3.13 Analyses of I and A Values: North Atlantic Ocean – Summer – 3-Hour Operation Period.

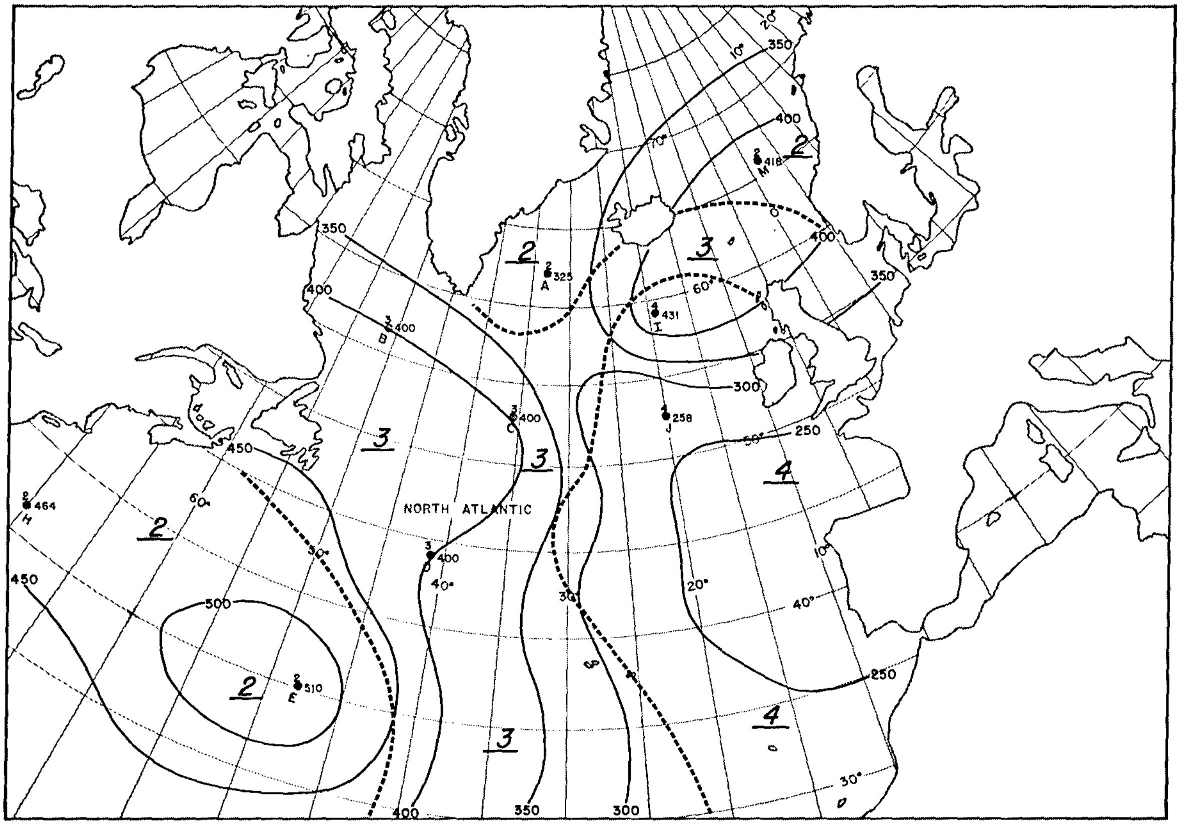



Figure 3.14 Analyses of I and A Values: North Atlantic Ocean – Fall – 3-Hour Operation Period.

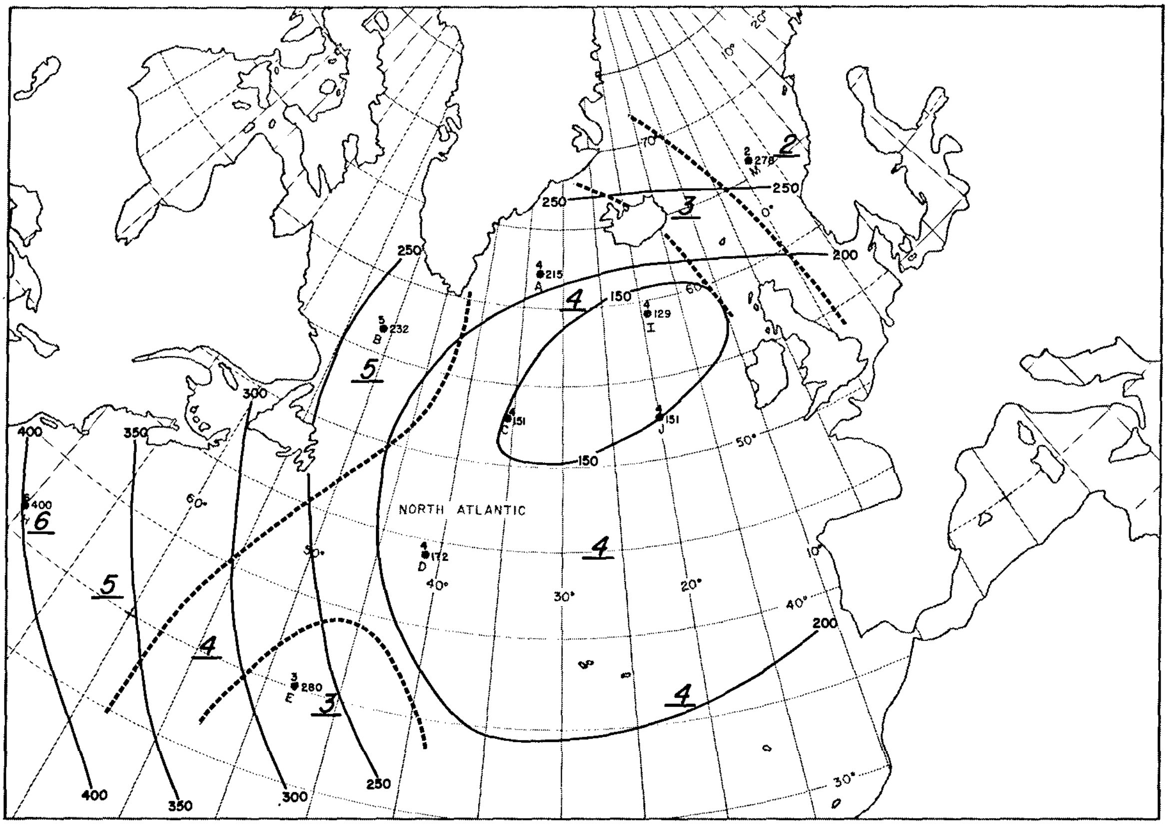



*Figure 3.15 Analyses of I and A Values: North Atlantic Ocean – Winter – 12-Hour Operation Period.*

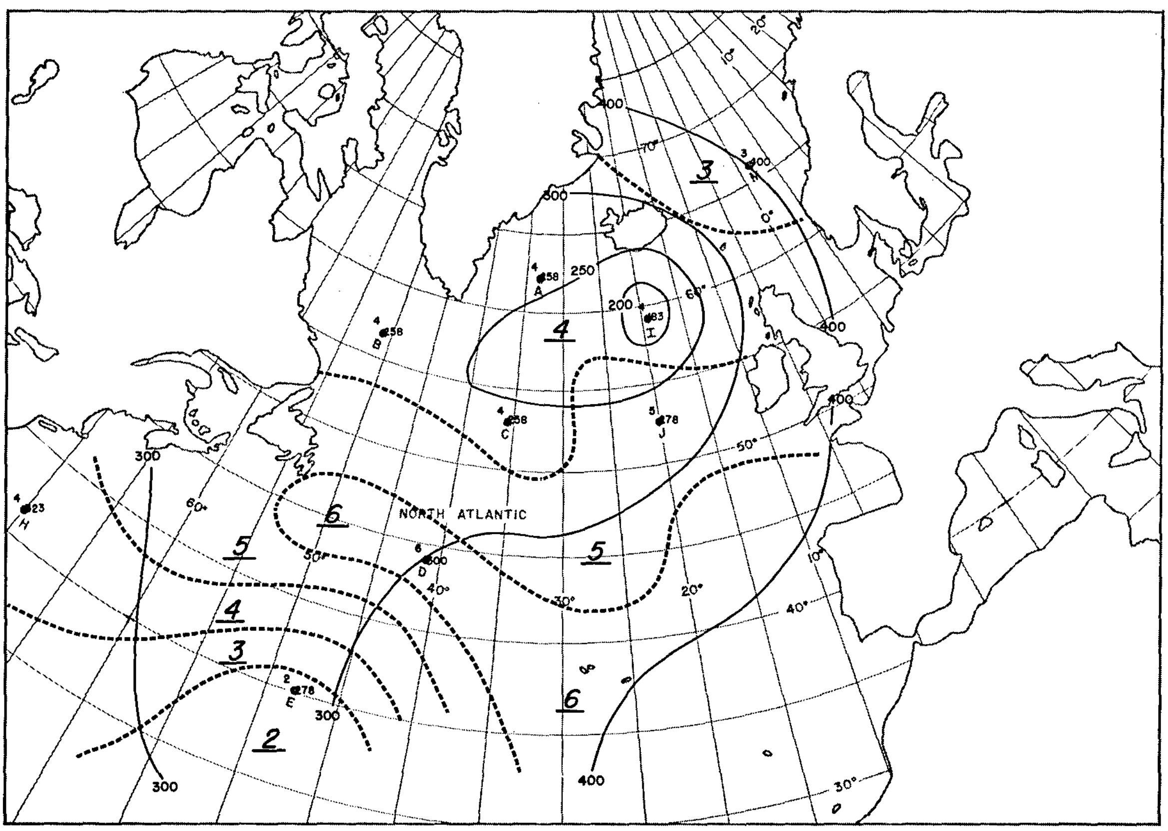



*Figure 3.16 Analyses of I and A Values: North Atlantic Ocean – Spring – 12-Hour Operation Period.*

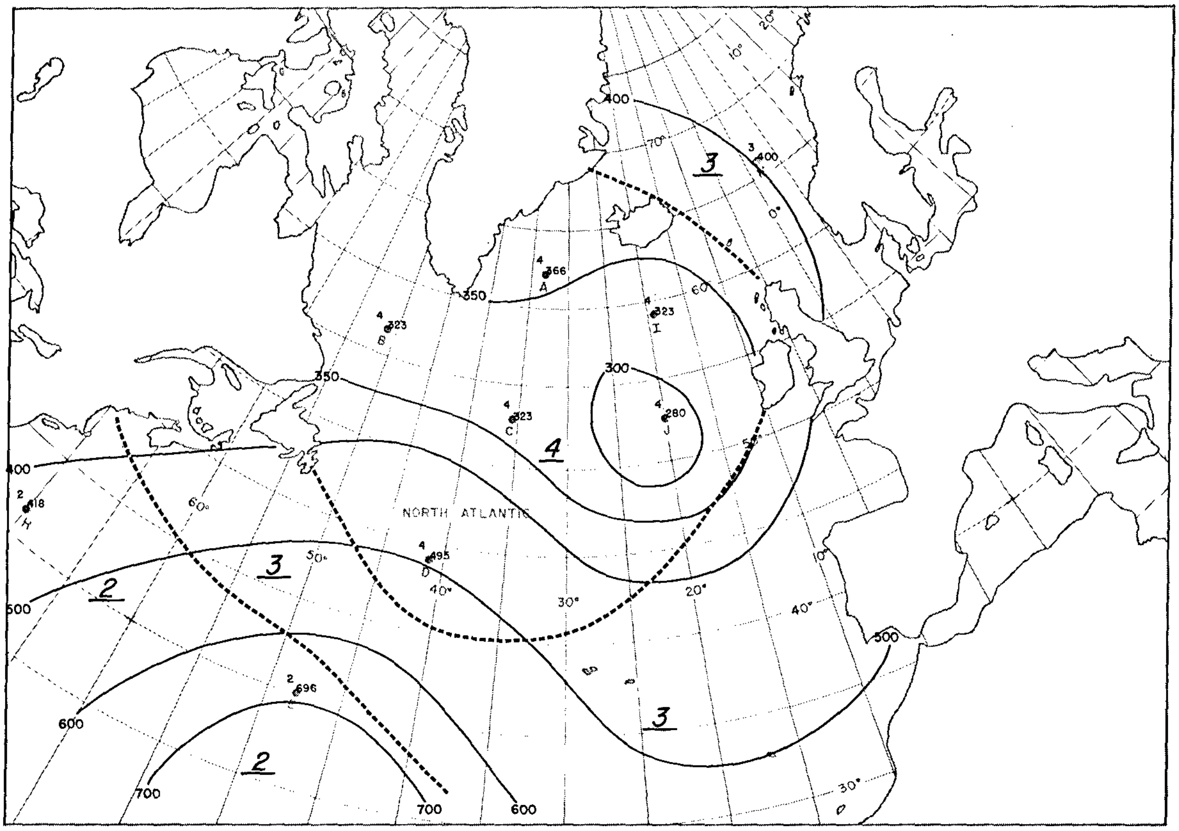



Figure 3.17 Analyses of I and A Values: North Atlantic Ocean – Summer – 12-Hour Operation Period.

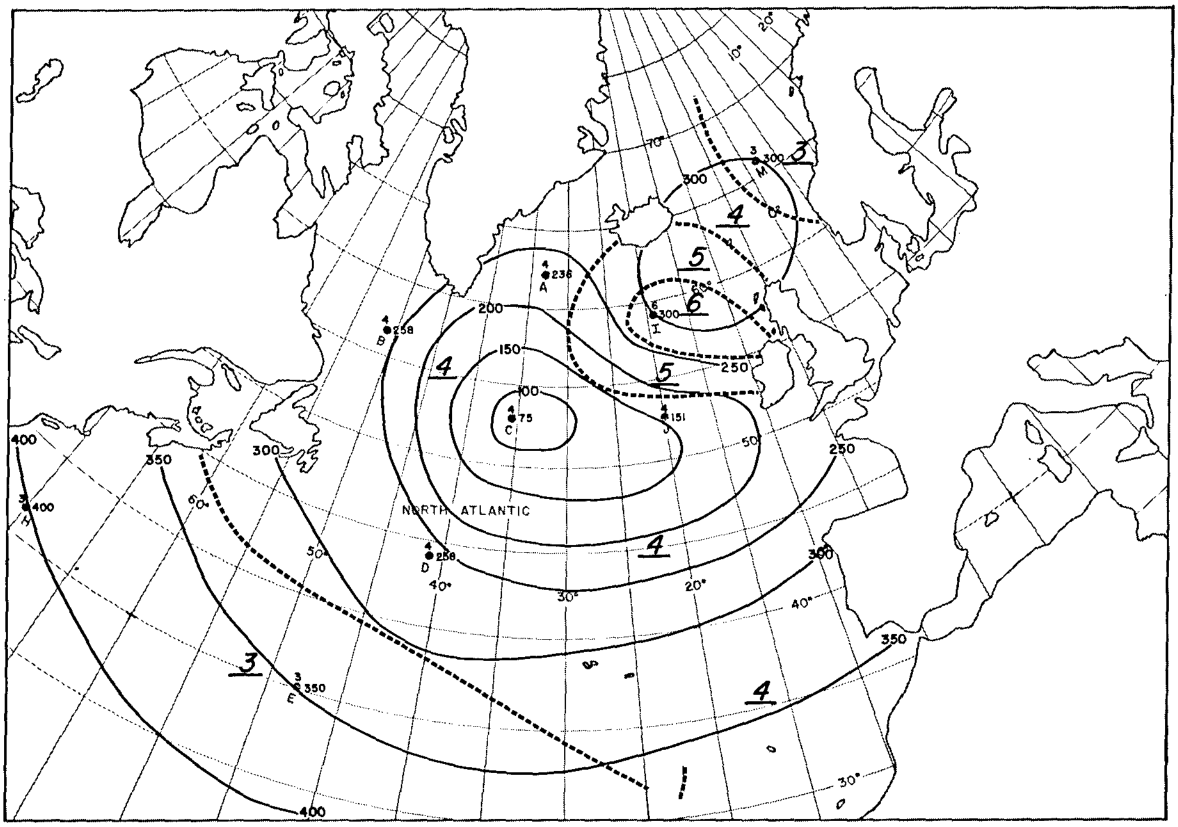



Figure 3.18 Analyses of I and A Values: North Atlantic Ocean – Fall – 12-Hour Operation Period.

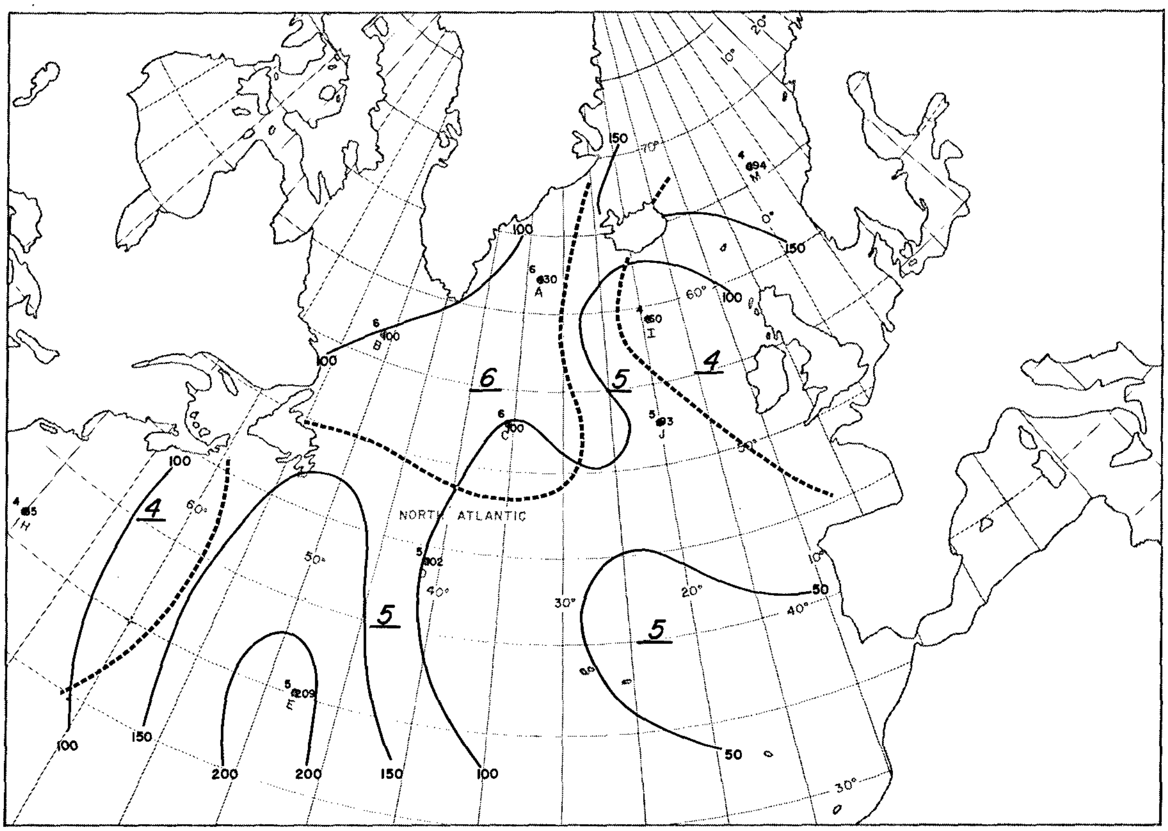



Figure 3.19 Analyses of I and A Values: North Atlantic Ocean – Winter – 24-Hour Operation Period.

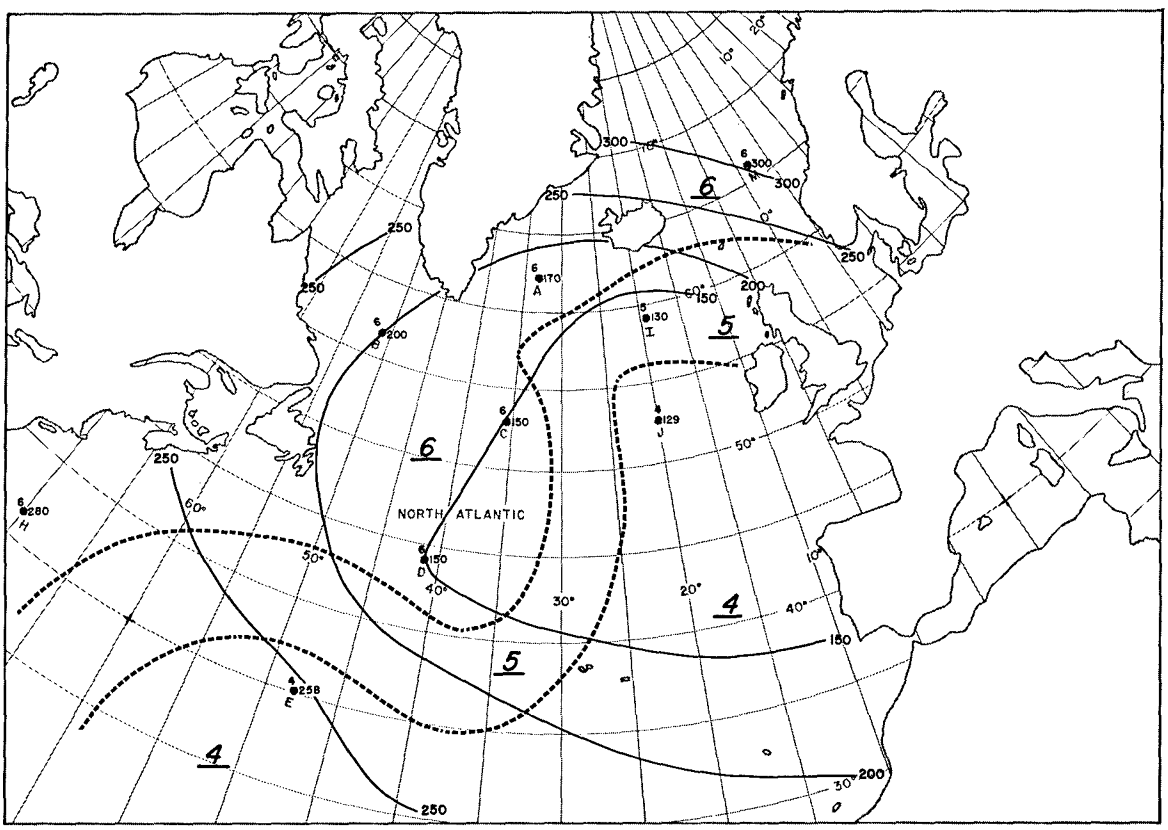



Figure 3.20 Analyses of I and A Values: North Atlantic Ocean – Spring – 24-Hour Operation Period.

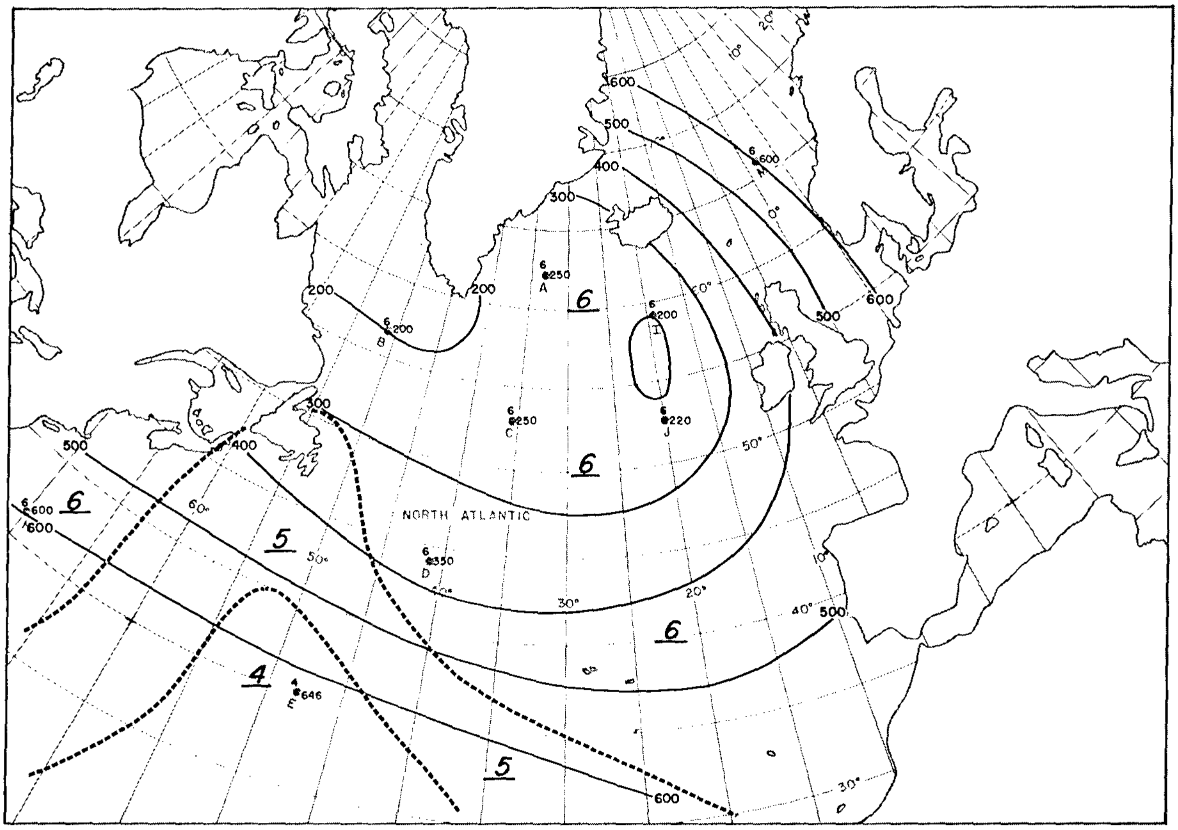



Figure 3.21 Analyses of I and A Values: North Atlantic Ocean – Summer – 24-Hour Operation Period.

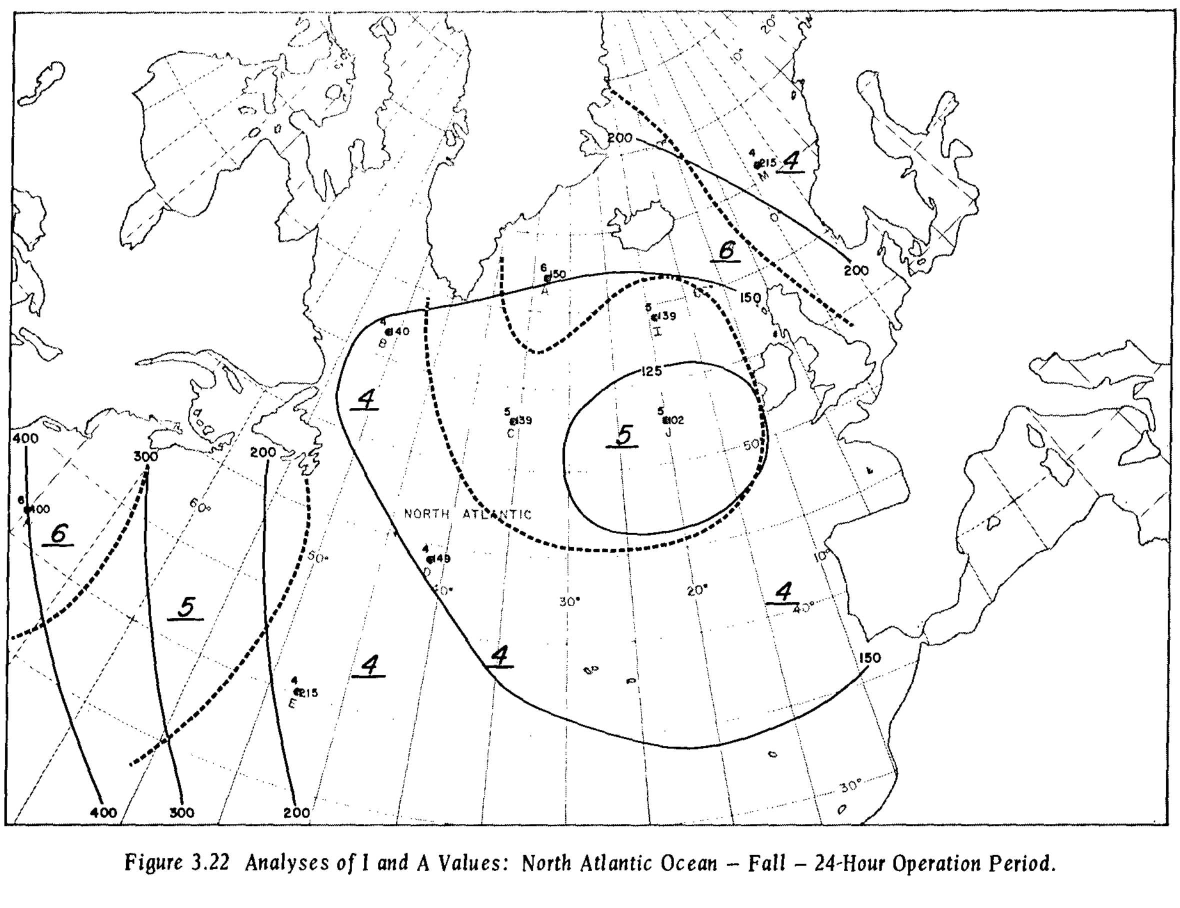



Figure 3.22 Analyses of I and A Values: North Atlantic Ocean – Fall – 24-Hour Operation Period.

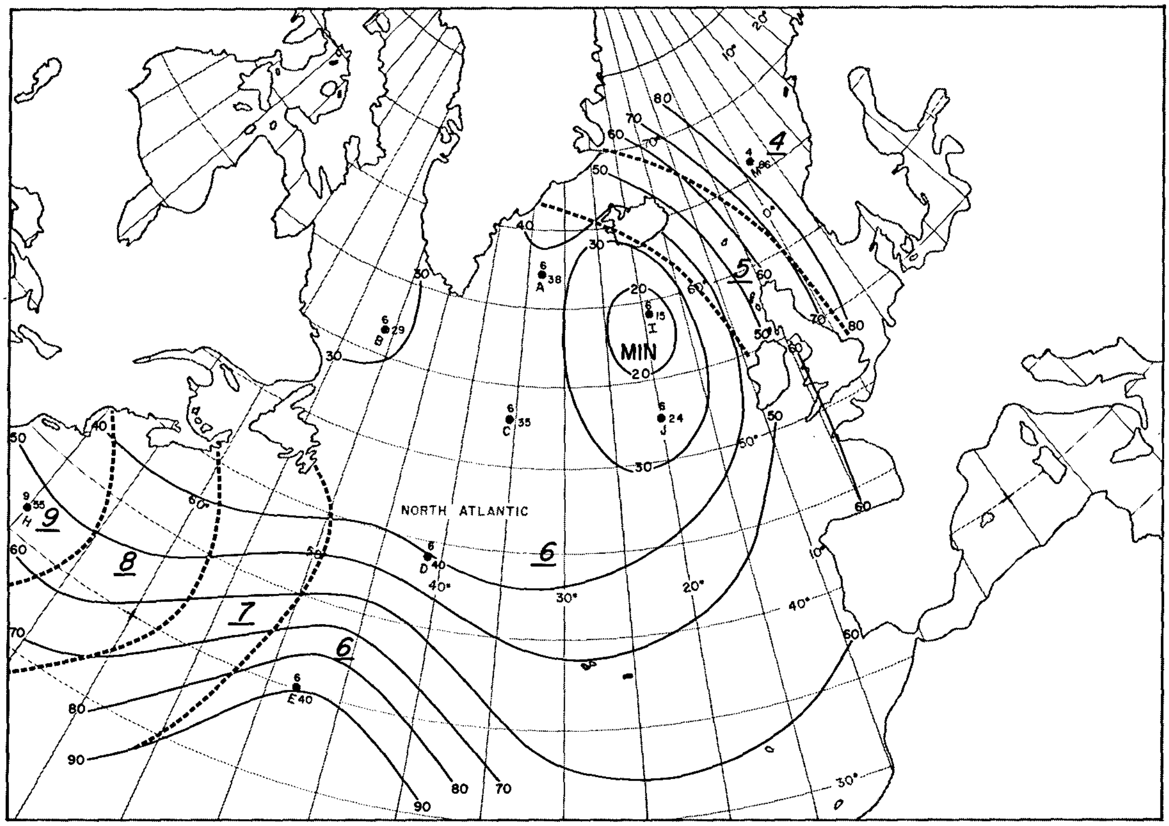



*Figure 3.23 Analyses of I and A Values: North Atlantic Ocean – Winter – 48-Hour Operation Period.*

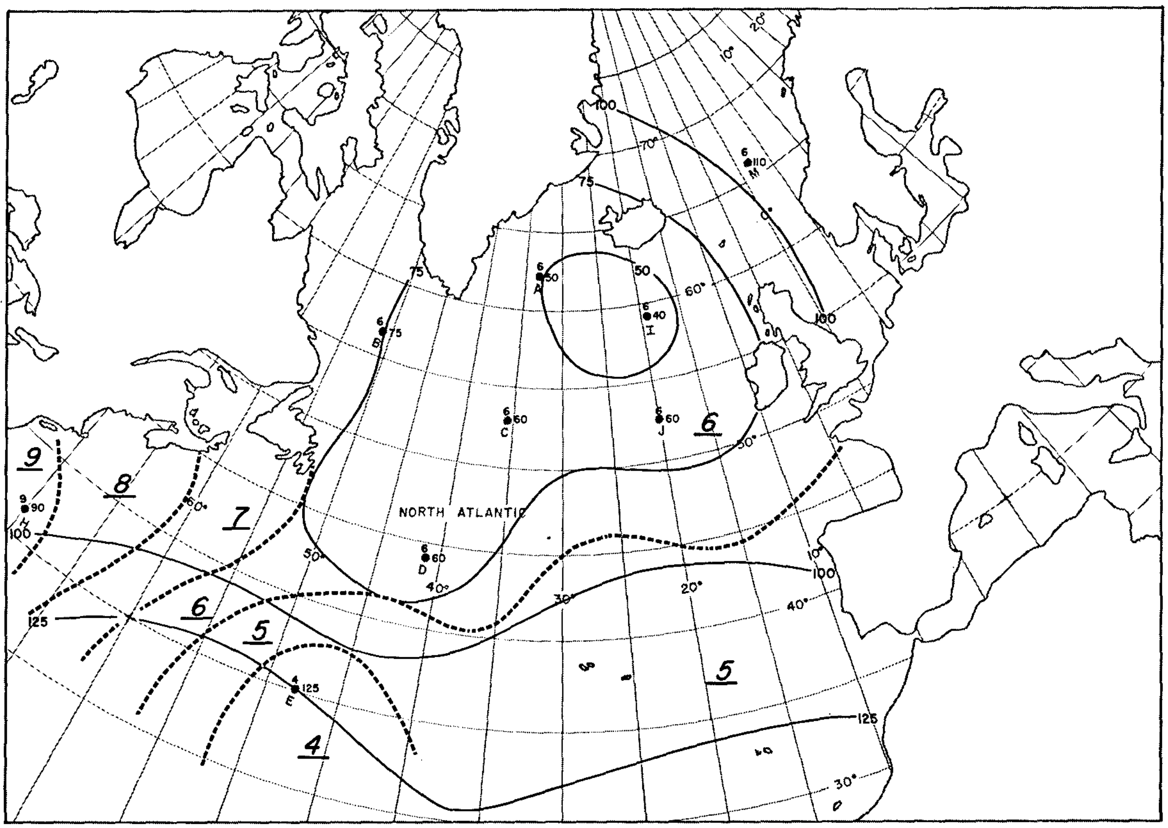



*Figure 3.24 Analyses of I and A Values: North Atlantic Ocean – Spring – 48-Hour Operation Period.*

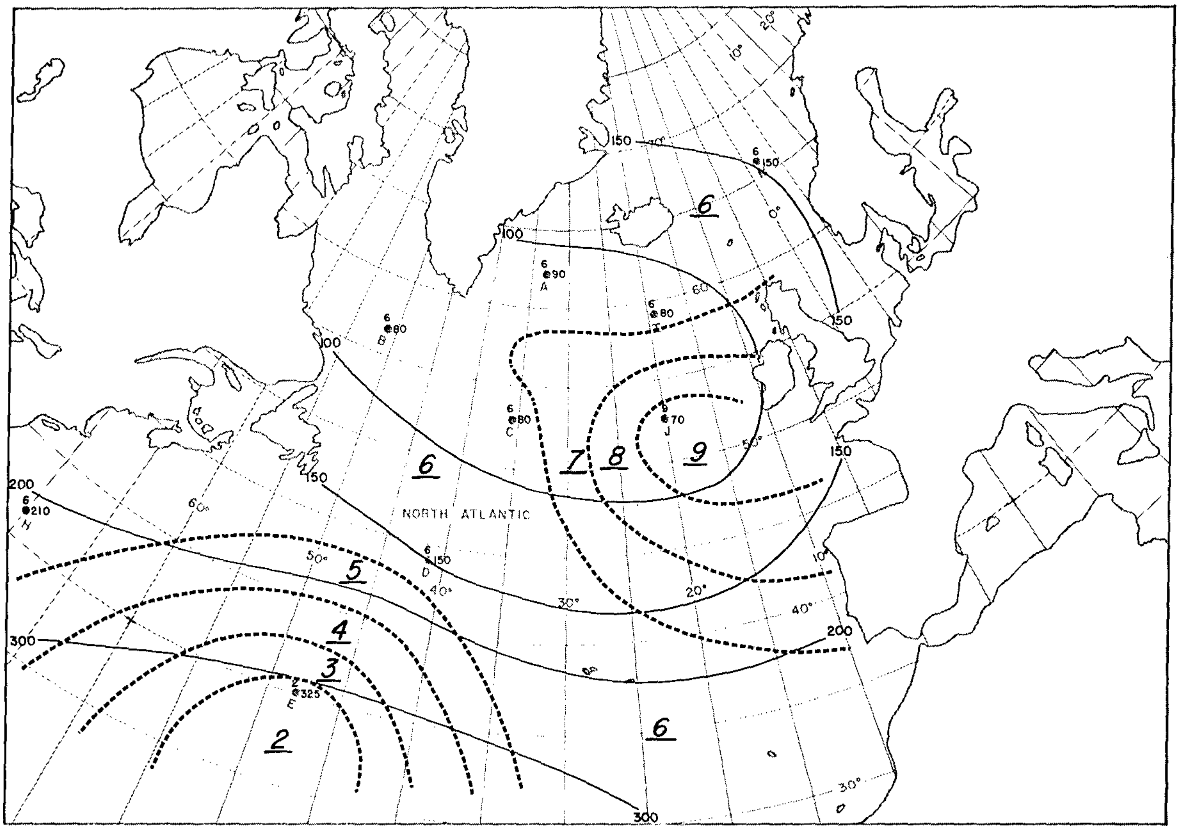



Figure 3.25 Analyses of I and A Values: North Atlantic Ocean – Summer – 48-Hour Operation Period.

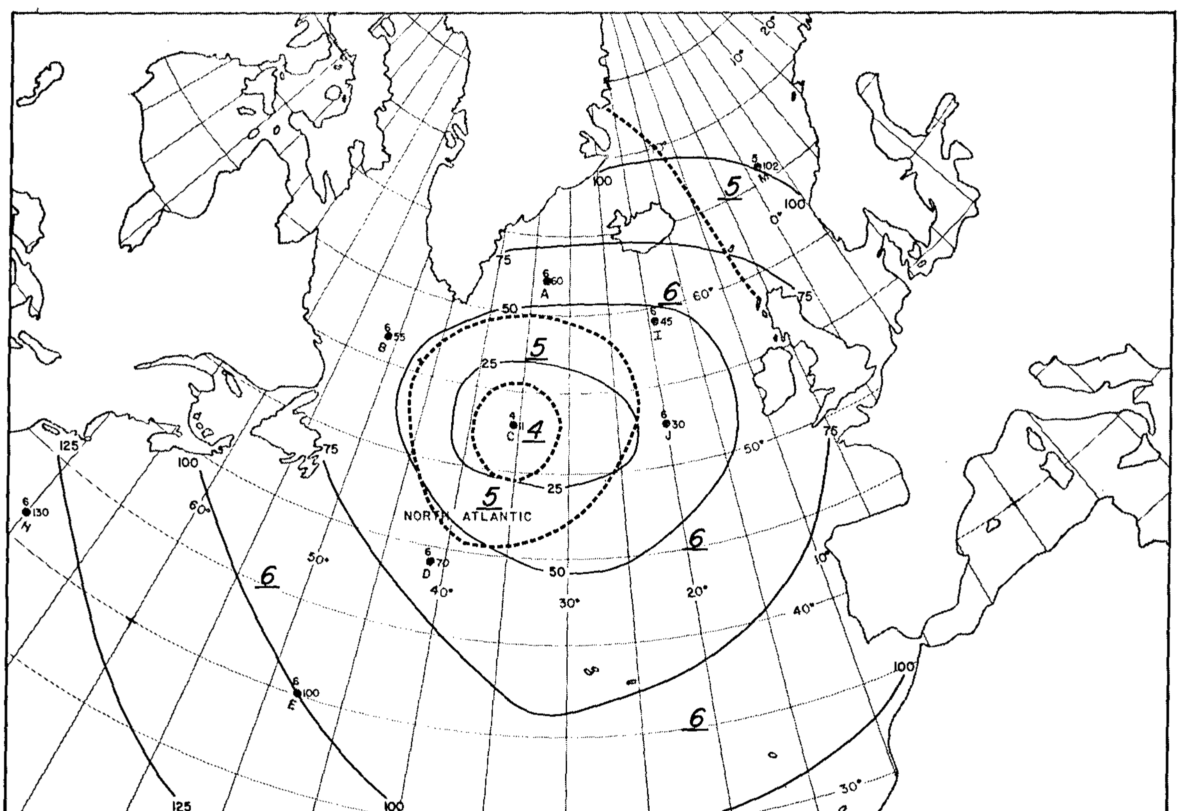



Figure 3.26 Analyses of I and A Values: North Atlantic Ocean – Fall – 48-Hour Operation Period.

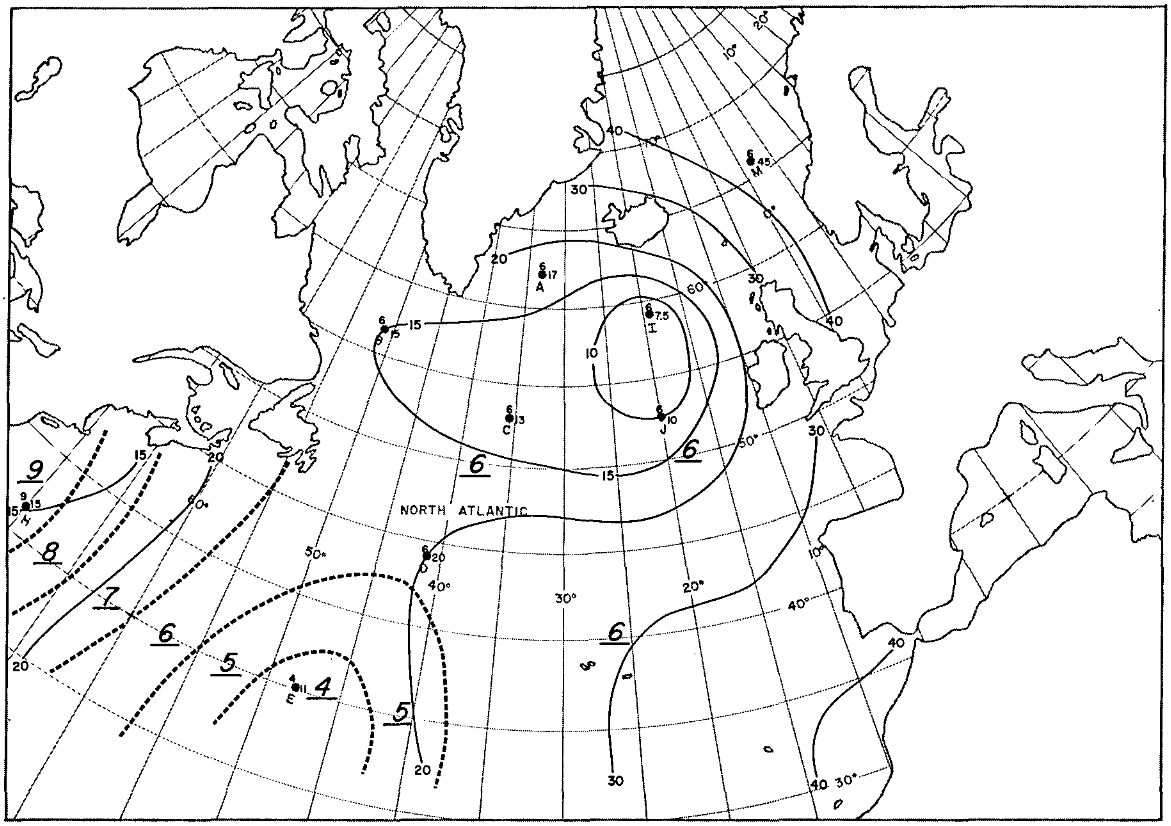



Figure 3.27 Analyses of I and A Values: North Atlantic Ocean – Winter – 72-Hour Operation Period.

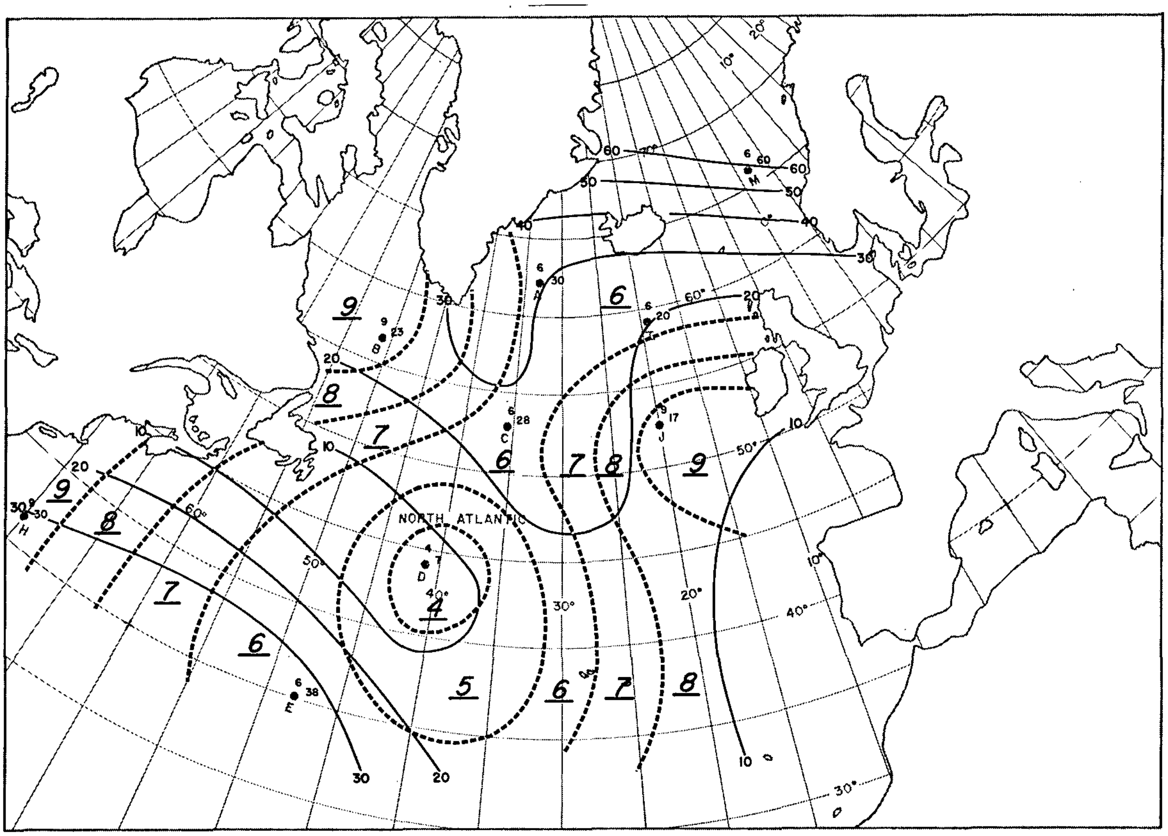



Figure 3.28 Analyses of I and A Values: North Atlantic Ocean – Spring – 72-Hour Operation Period.

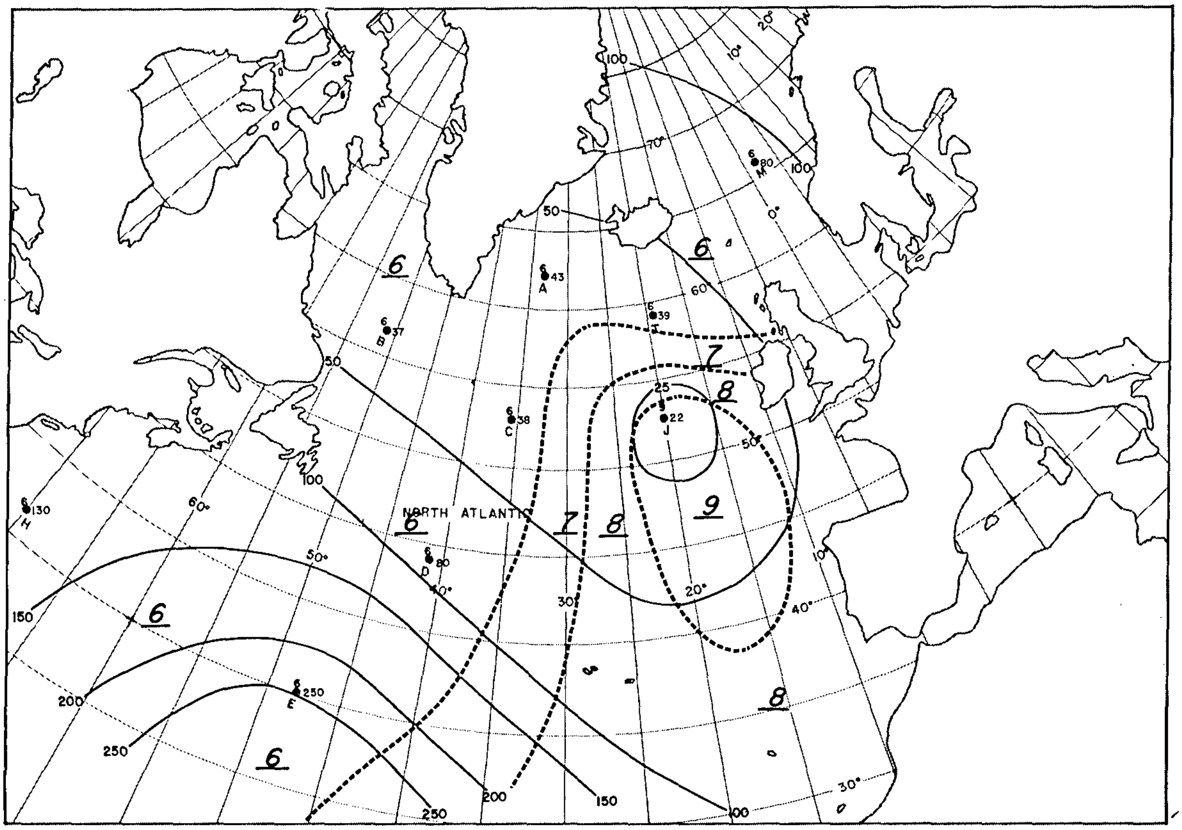



Figure 3.29 Analyses of I and A Values: North Atlantic Ocean – Summer – 72-Hour Operation Period.

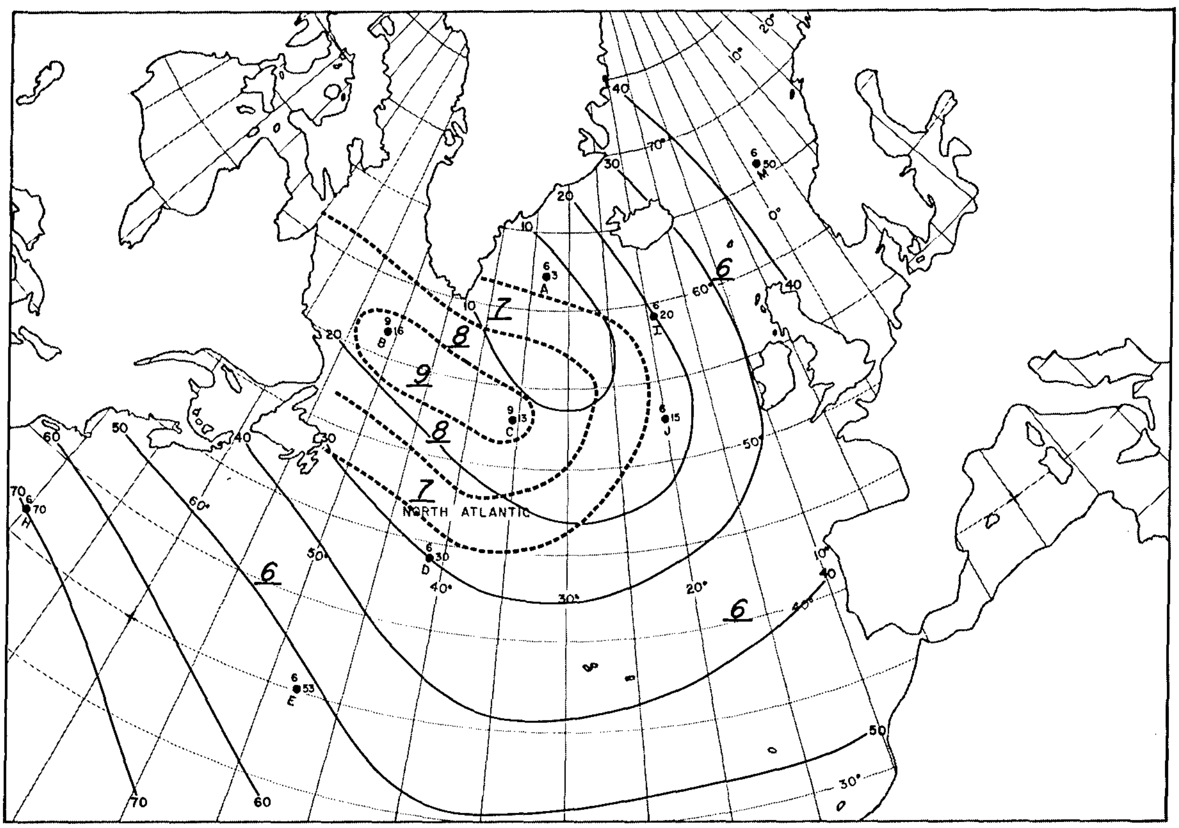



Figure 3.30 Analyses of I and A Values: North Atlantic Ocean – Fall – 72-Hour Operation Period.

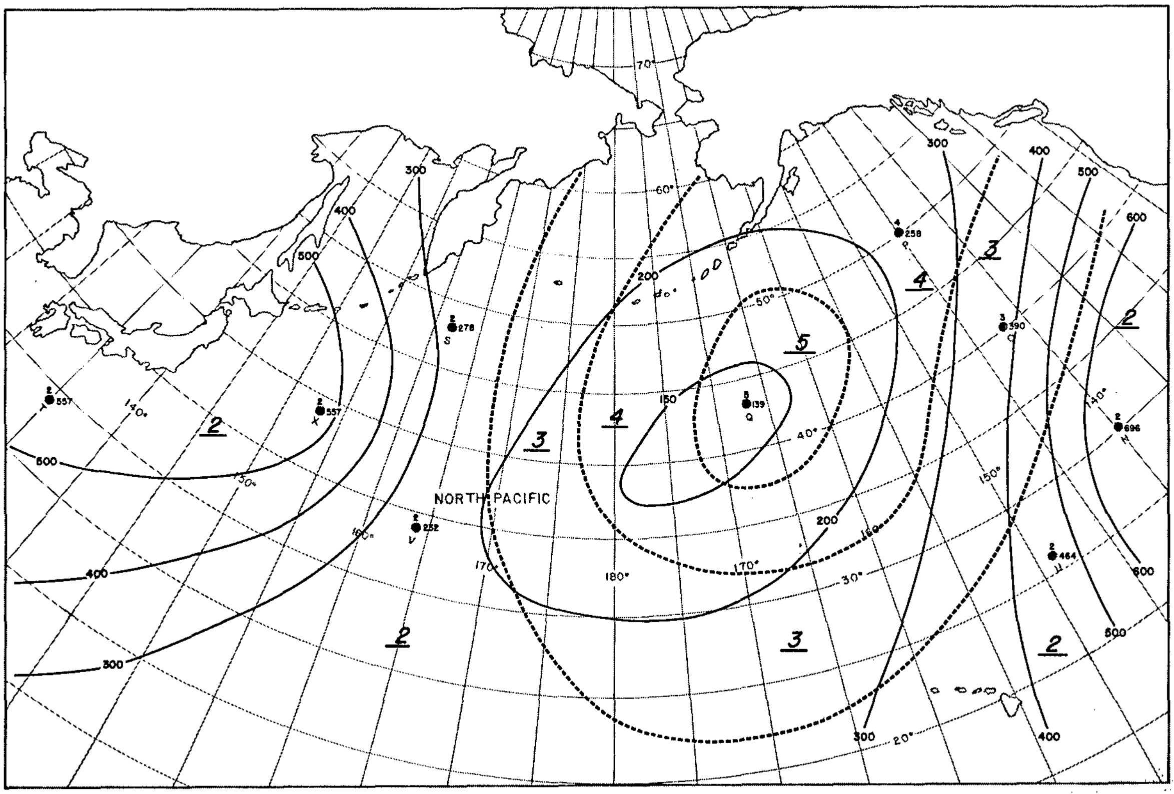



Figure 3.31 Analyses of I and A Values: North Pacific Ocean – Winter – 3-Hour Operation Period.

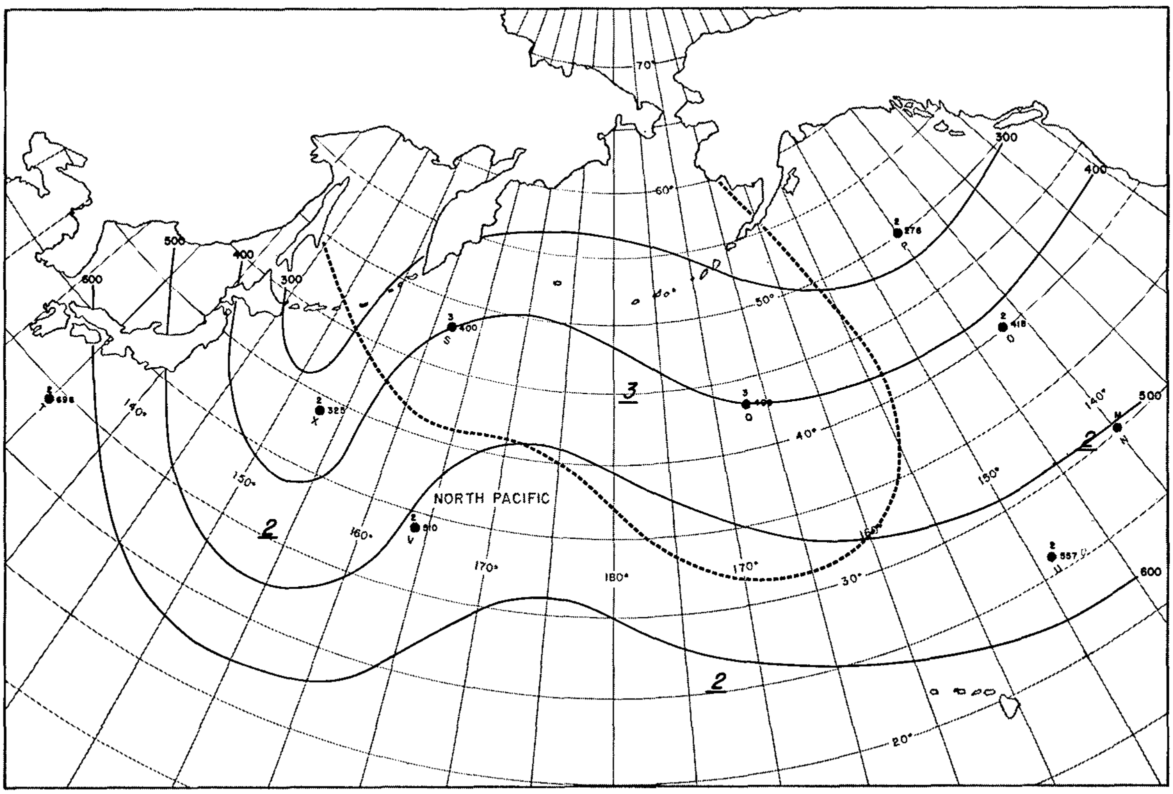



Figure 3.32 Analyses of I and A Values: North Pacific Ocean – Spring – 3-Hour Operation Period.

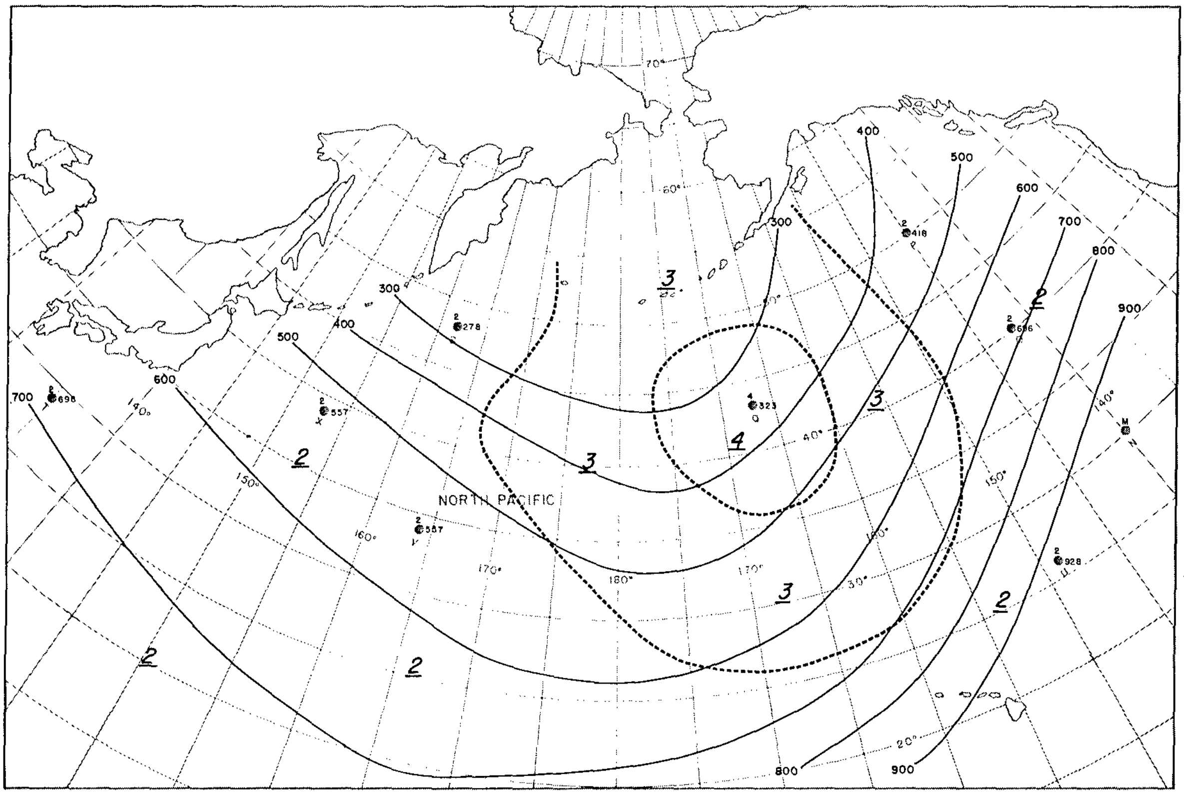


Figure 3.33 Analyses of I and A Values: North Pacific Ocean – Summer – 3-Hour Operation Period.

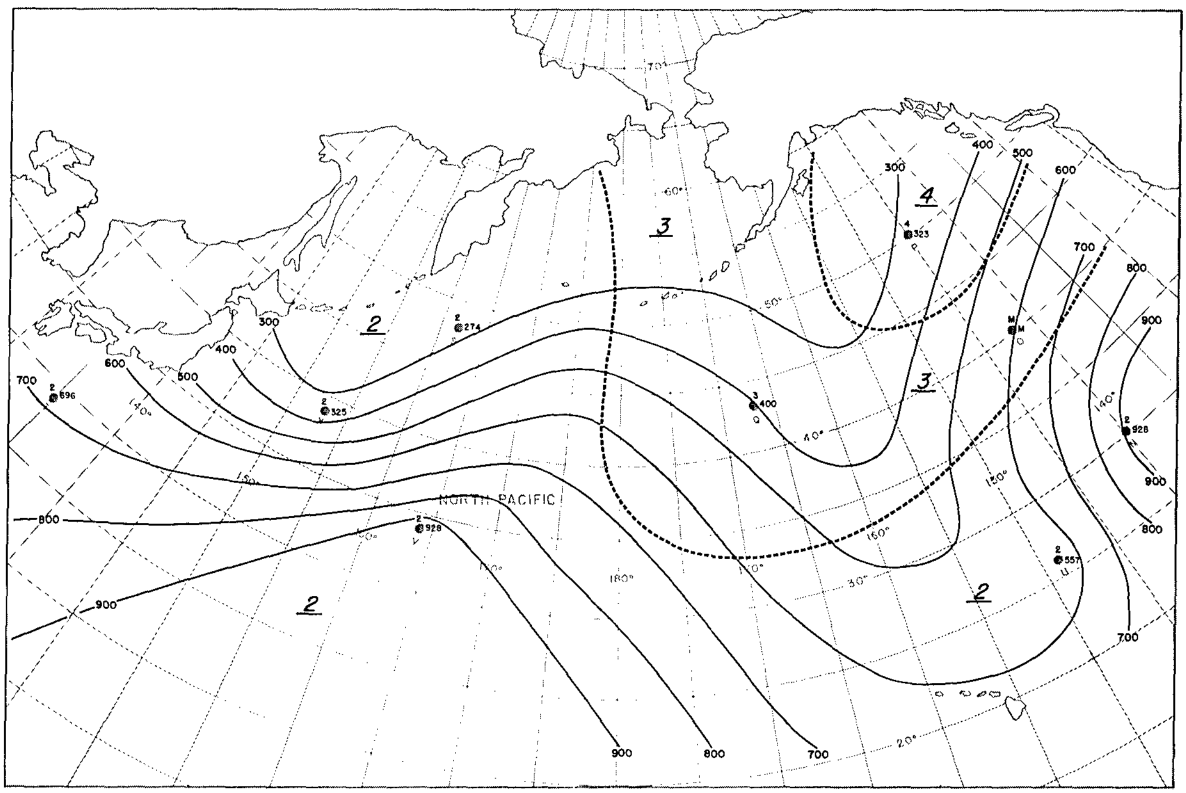


Figure 3.34 Analyses of I and A Values: North Pacific Ocean – Fall – 3-Hour Operation Period.

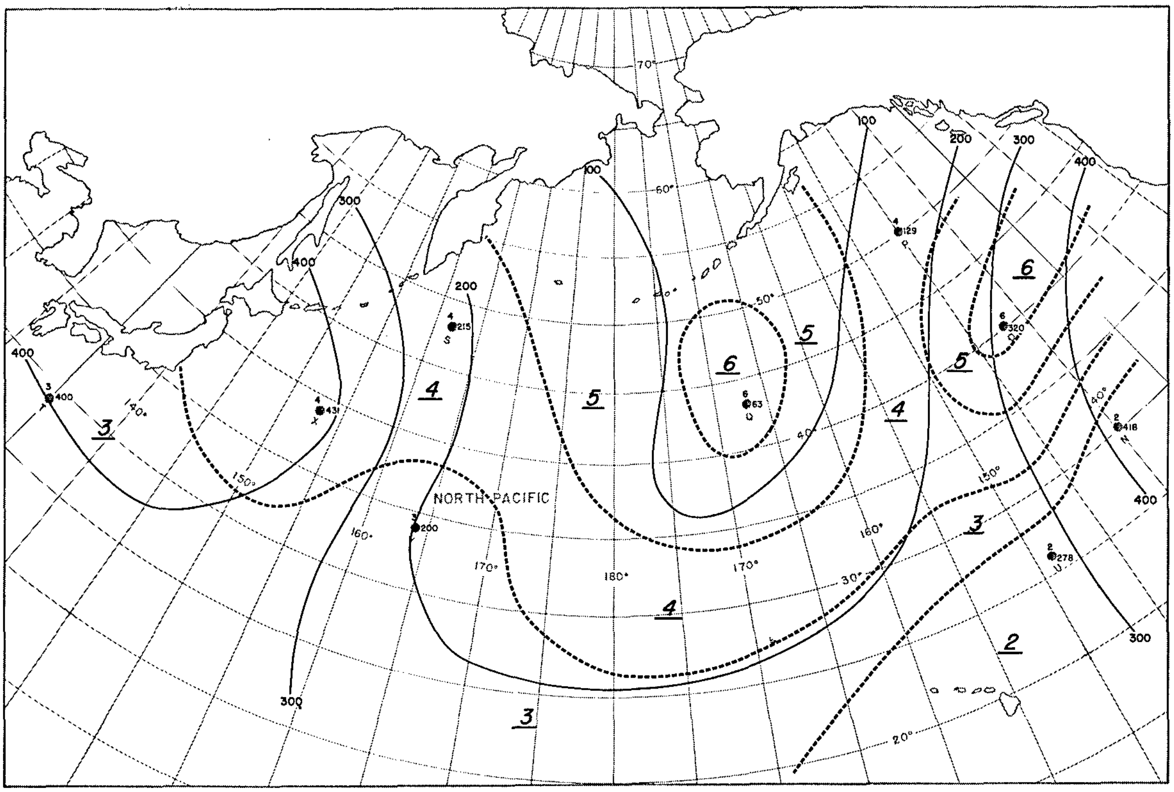



*Figure 3.35 Analyses of I and A Values: North Pacific Ocean – Winter – 12-Hour Operation Period.*

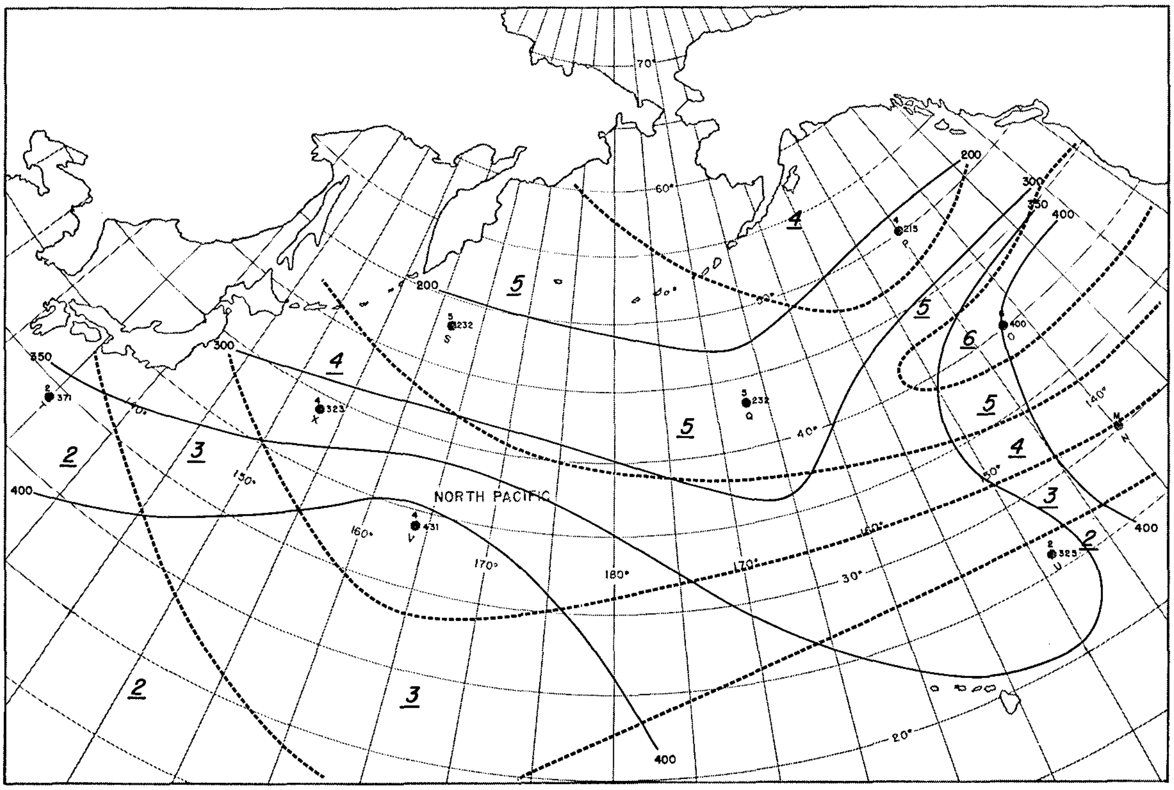



*Figure 3.36 Analyses of I and A Values: North Pacific Ocean – Spring – 12-Hour Operation Period.*

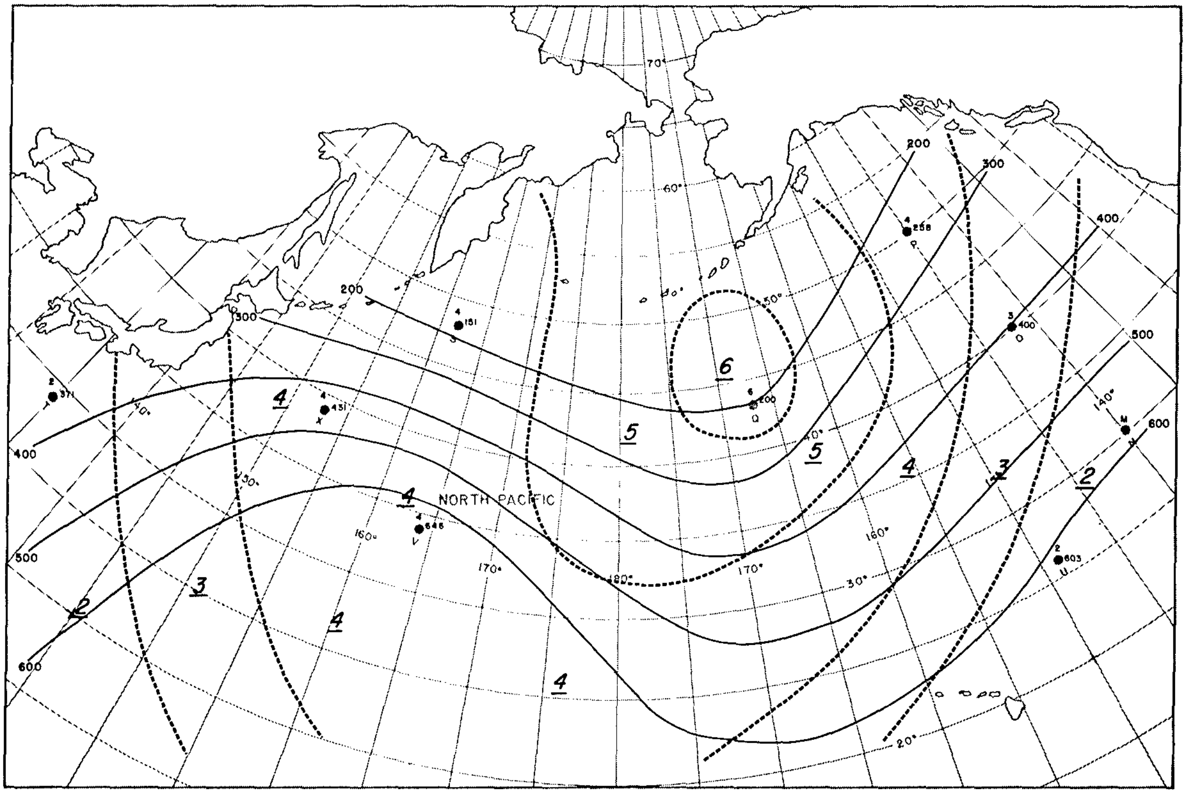



*Figure 3.37 Analyses of I and A Values: North Pacific Ocean – Summer – 12-Hour Operation Period.*

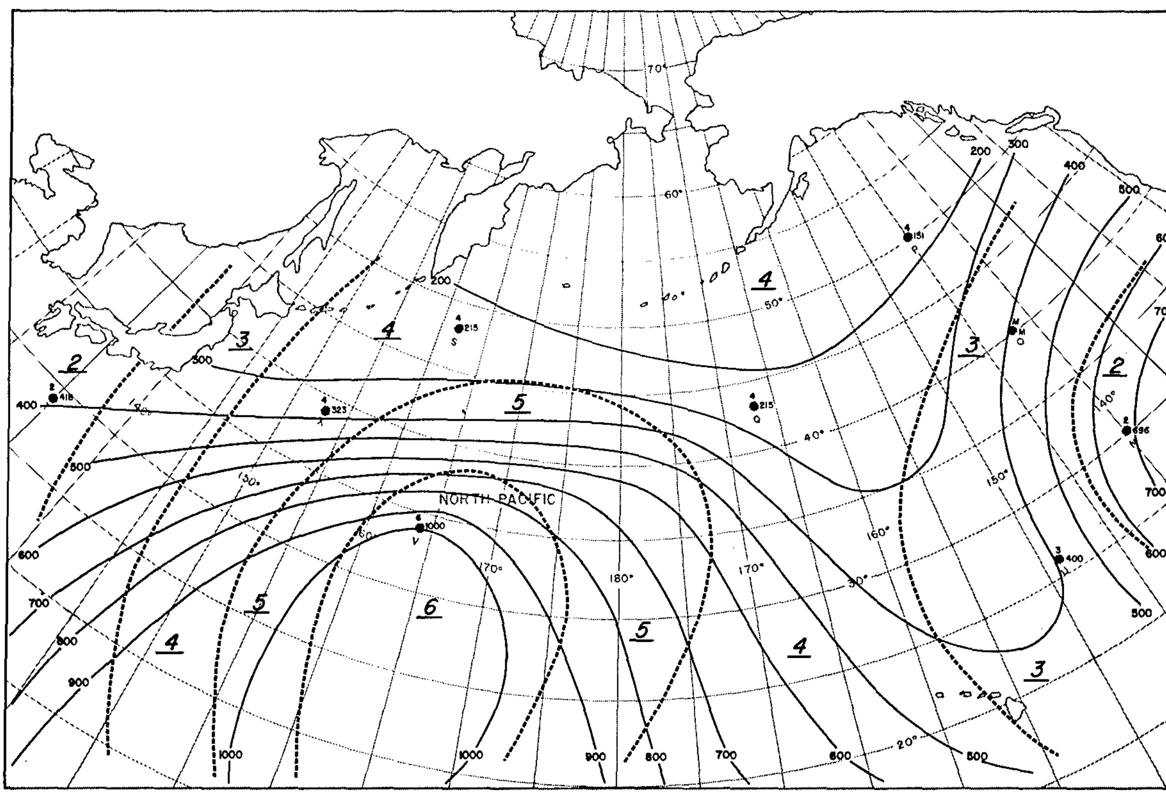



*Figure 3.38 Analyses of I and A Values: North Pacific Ocean – Fall – 12-Hour Operation Period.*

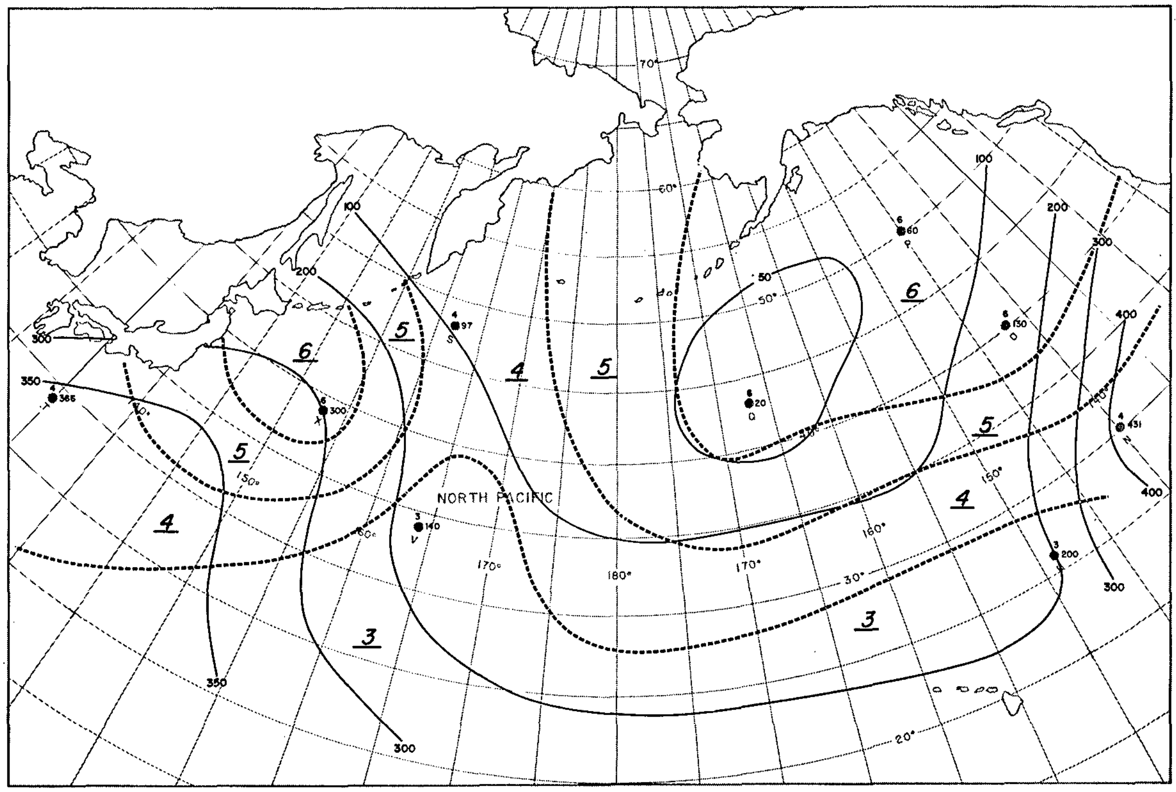



*Figure 3.39 Analyses of Ī and Ā Values: North Pacific Ocean – Winter – 24-Hour Operation Period.*

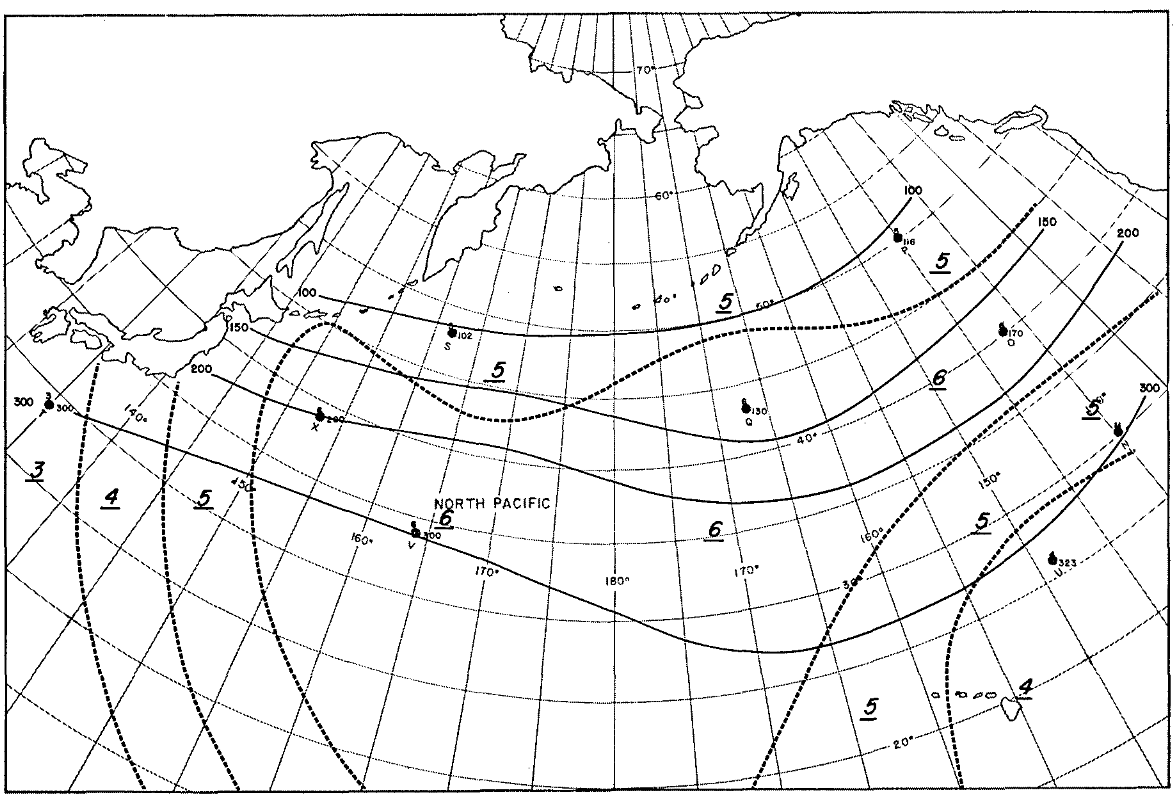



*Figure 3.40 Analyses of I and A Values: North Pacific Ocean – Spring – 24-Hour Operation Period.*

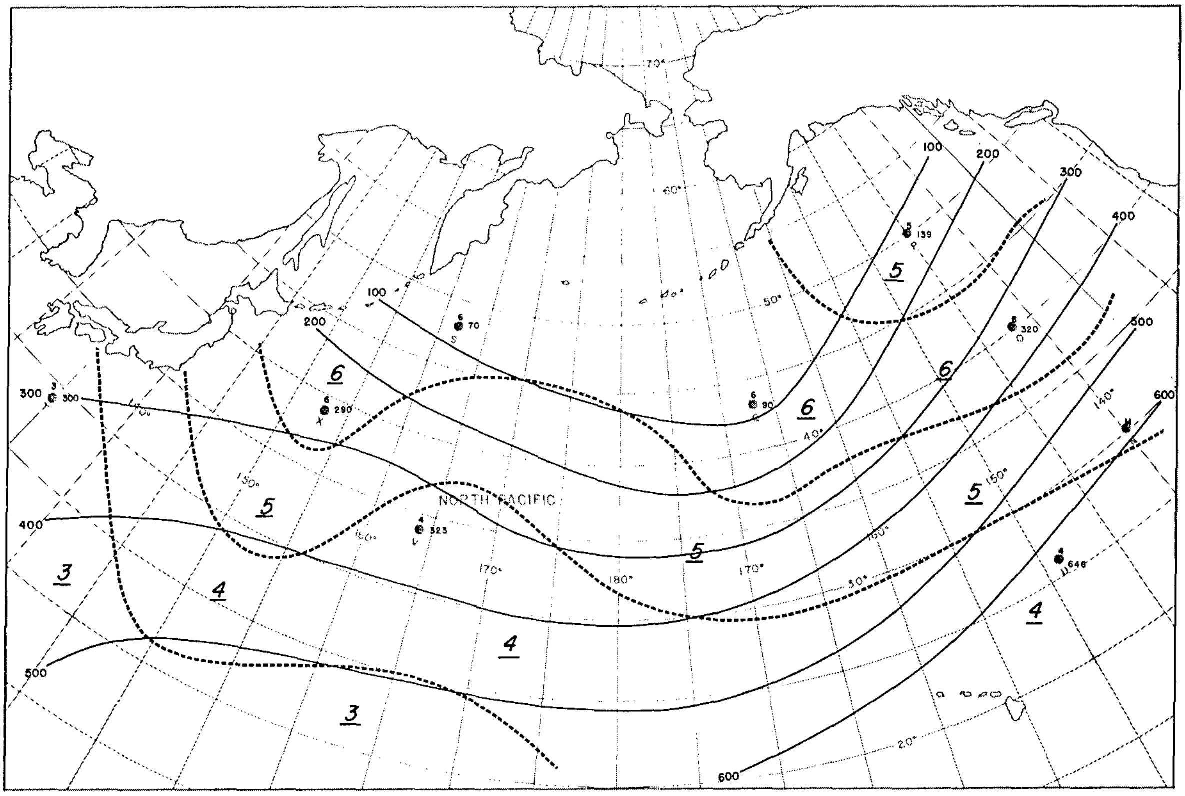



*Figure 3.41 Analyses of I and A Values: North Pacific Ocean – Summer – 24-Hour Operation Period.*

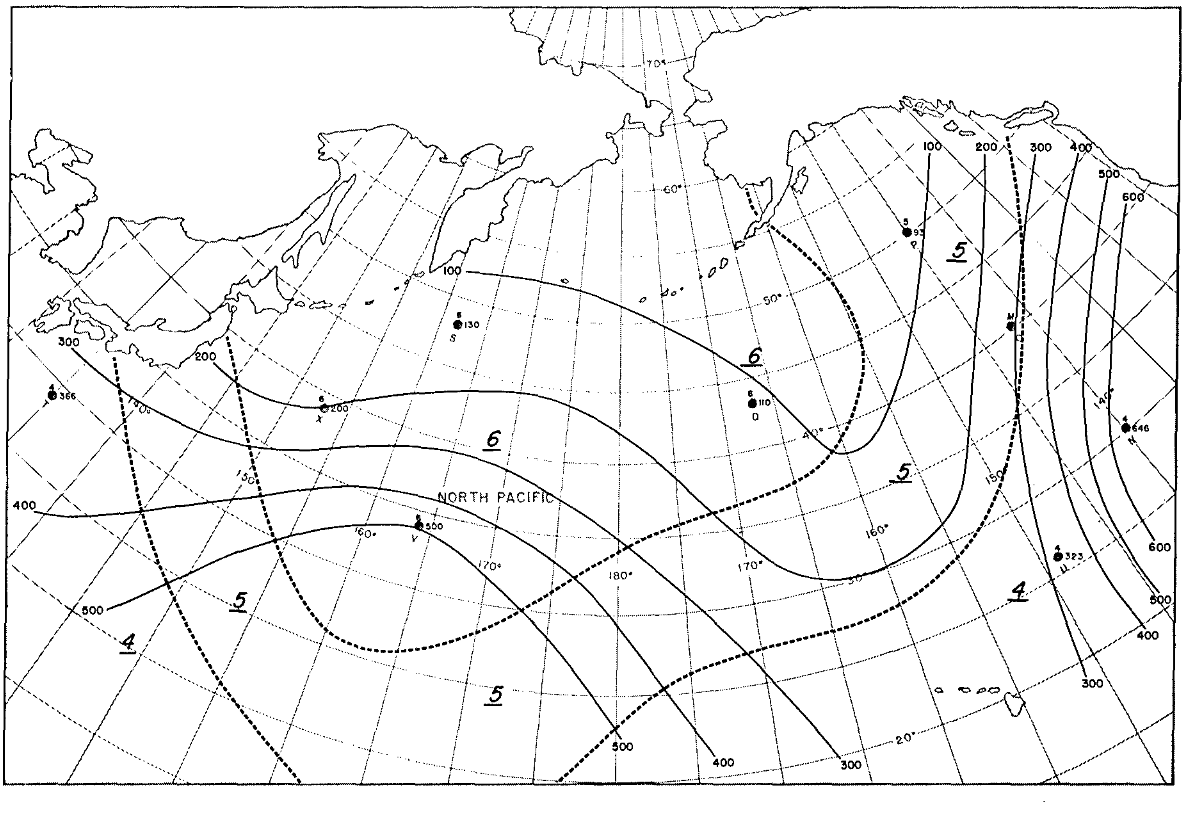



*Figure 3.42 Analyses of I and A Values: North Pacific Ocean – Fall – 24-Hour Operation Period.*

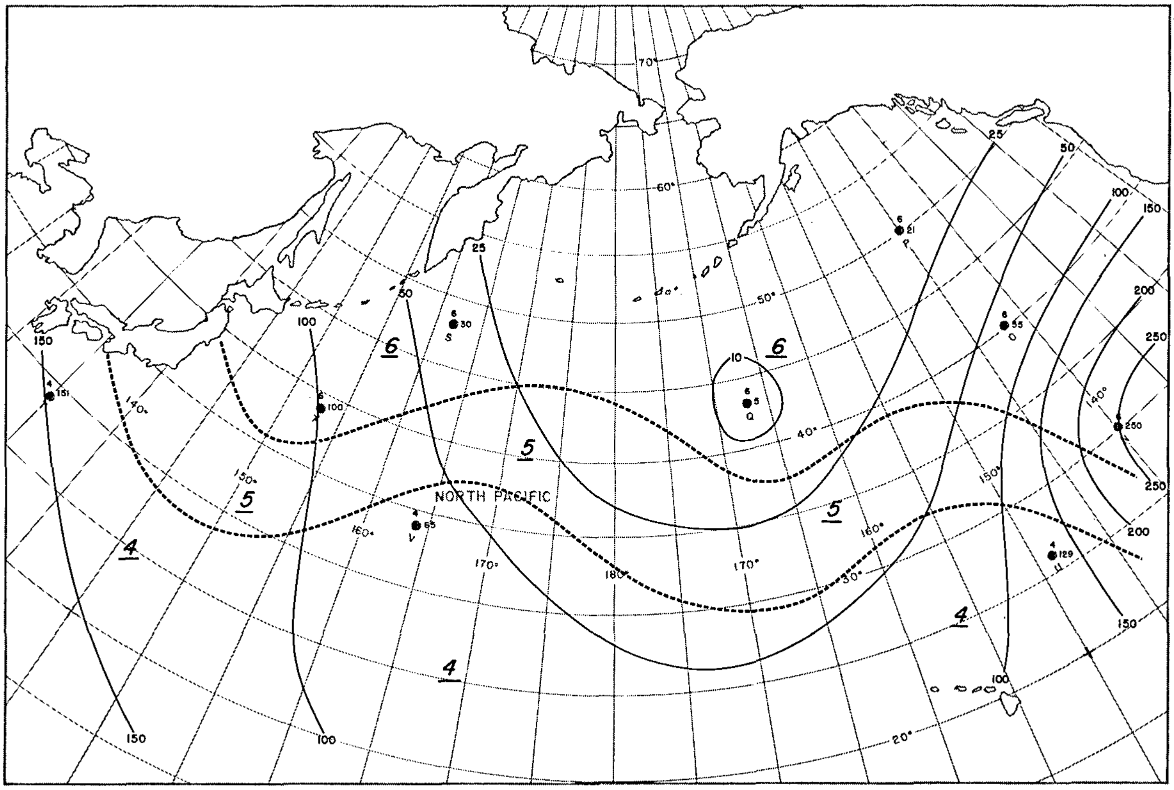



Figure 3.43 Analyses of I and A Values: North Pacific Ocean – Winter – 48-Hour Operation Period.

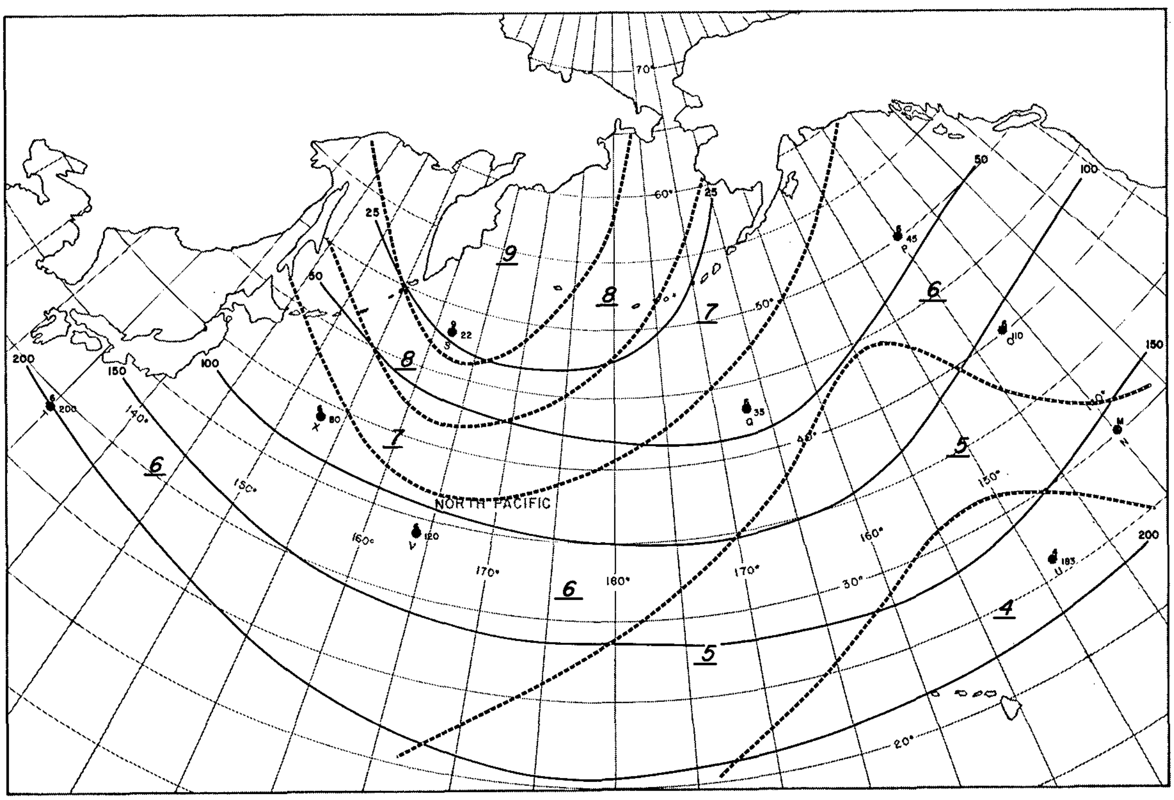



Figure 3.44 Analyses of I and A Values: North Pacific Ocean – Spring – 48-Hour Operation Period.

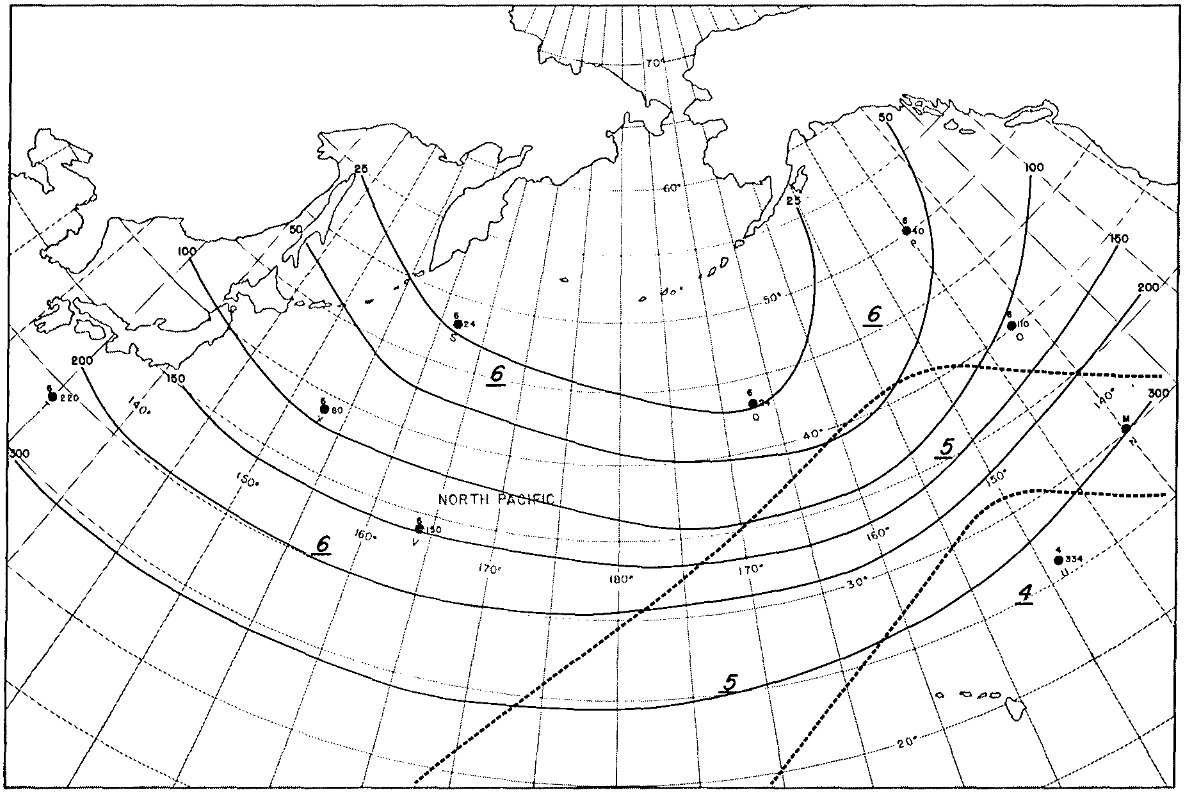



Figure 3.45 Analyses of I and A Values: North Pacific Ocean – Summer – 48-Hour Operation Period.

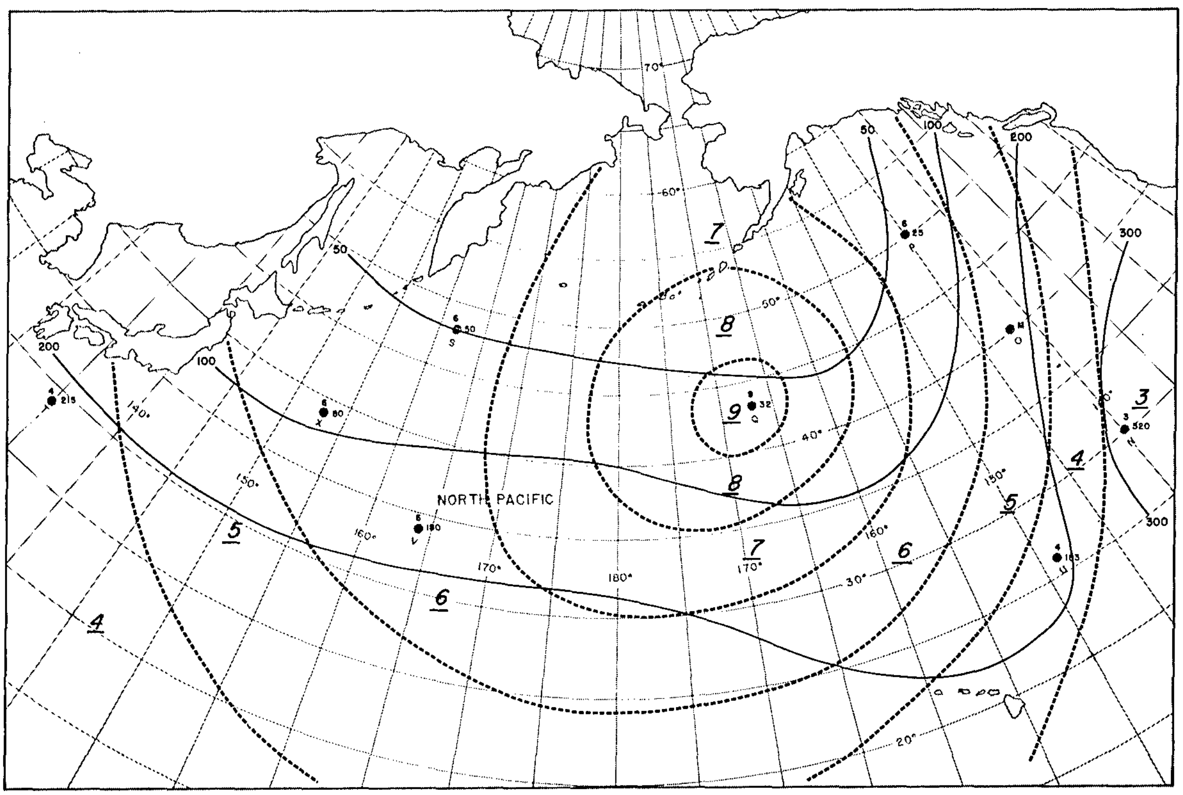



Figure 3.46 Analyses of I and A Values: North Pacific Ocean – Fall – 48-Hour Operation Period.

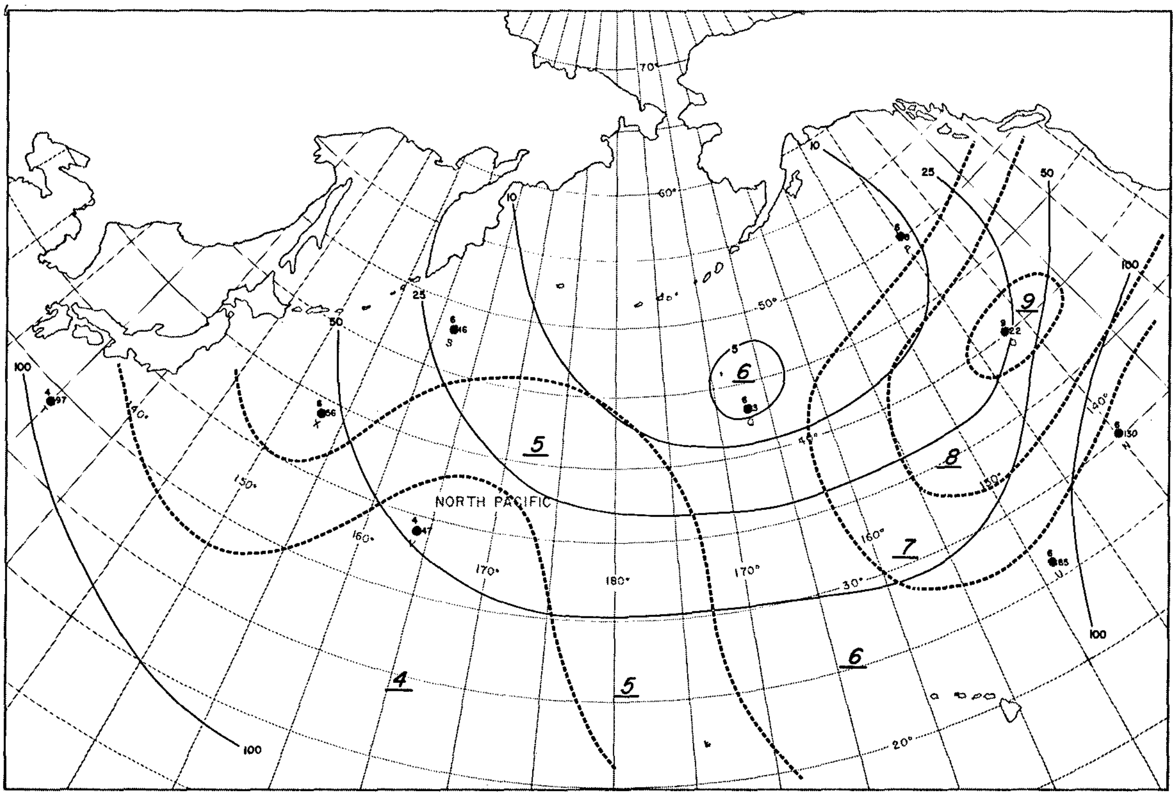



Figure 3.47 Analyses of Ī and A Values: North Pacific Ocean – Winter – 72-Hour Operation Period.

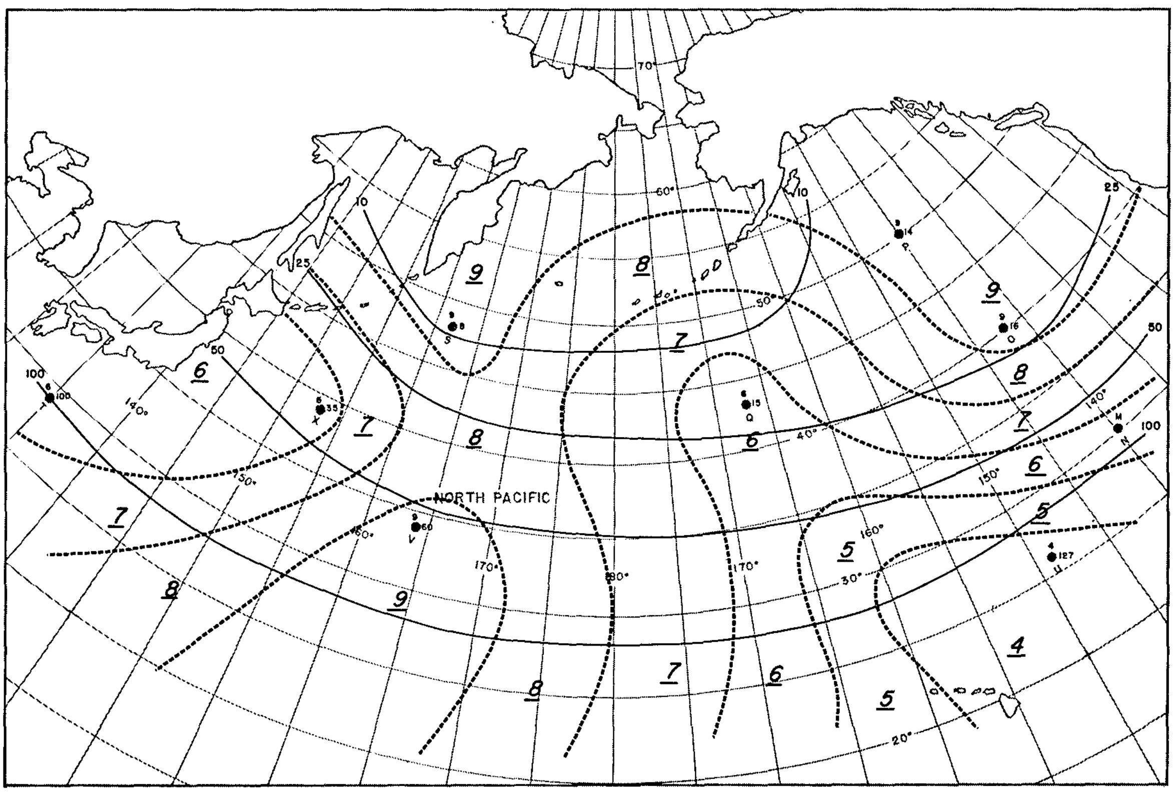



Figure 3.48 Analyses of I and A Values: North Pacific Ocean – Spring – 72-Hour Operation Period.

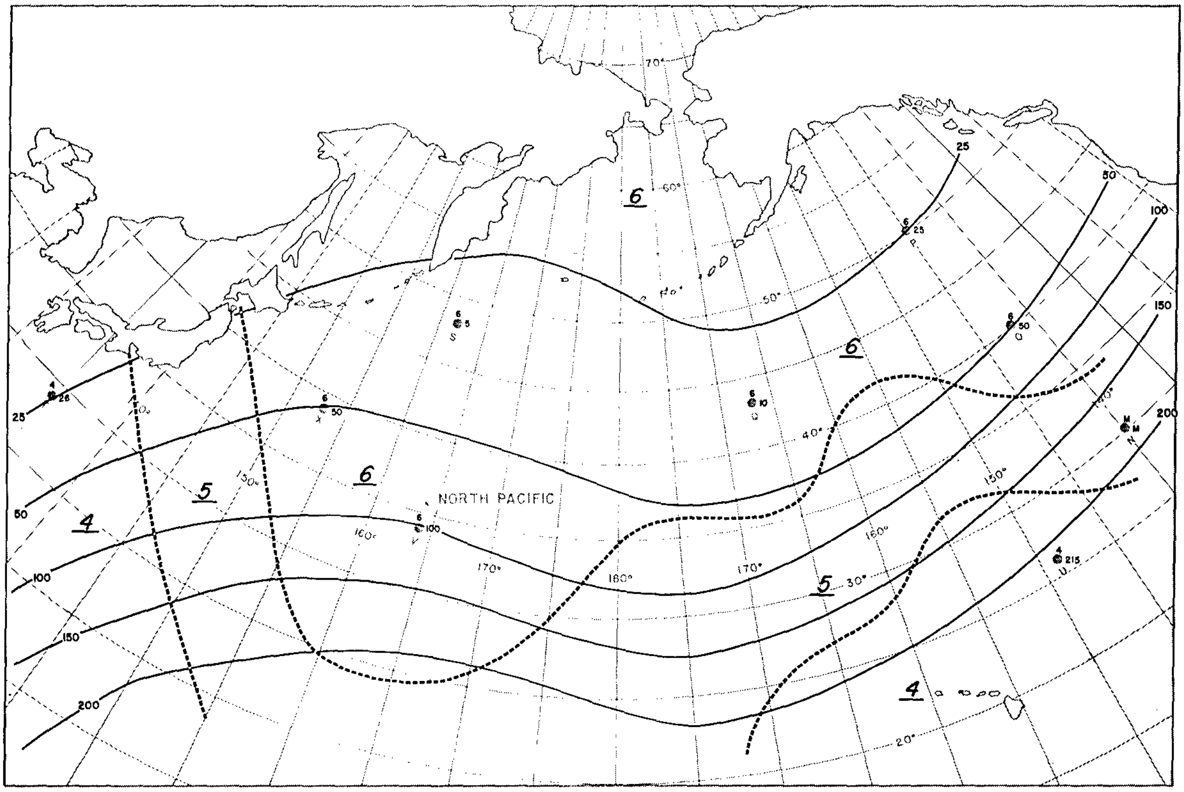



Figure 3.49 Analyses of I and A Values: North Pacific Ocean – Summer – 72-Hour Operation Period.

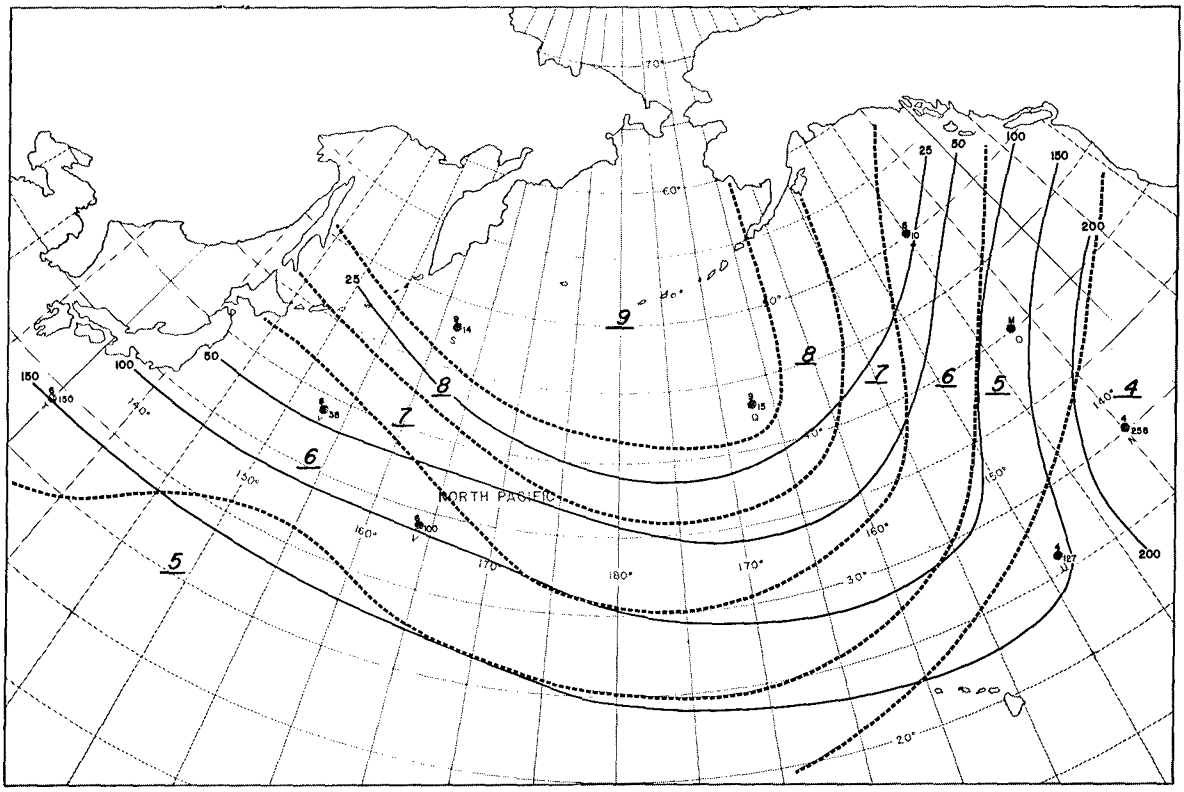



Figure 3.50 Analyses of I and A Values: North Pacific Ocean – Fall – 72-Hour Operation Period.

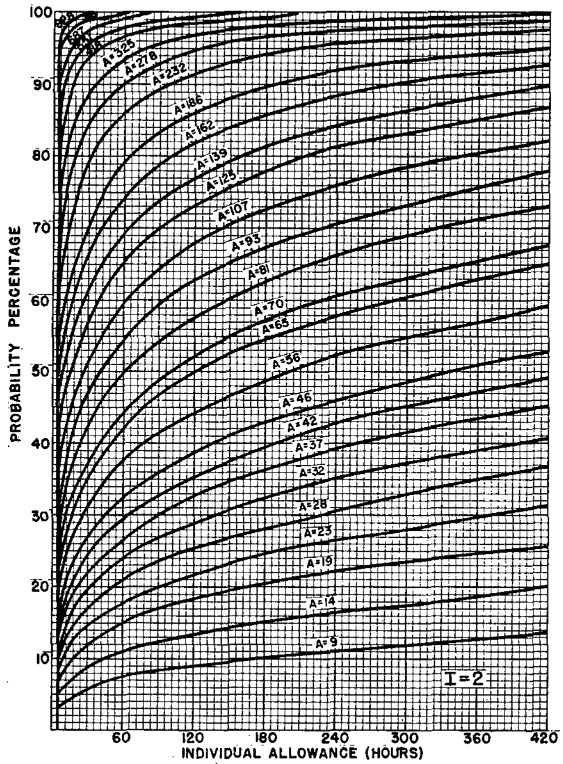



*Figure 3.51 Type II Individual Allowance A Curves (Generated): I Value of 2.*

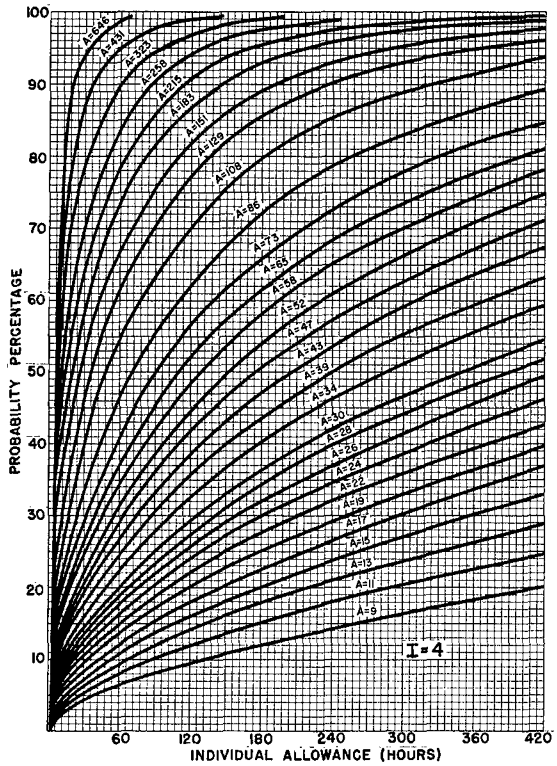



*Figure 3.53 Type II Individual Allowance A Curves (Generated): I Value of 4.*

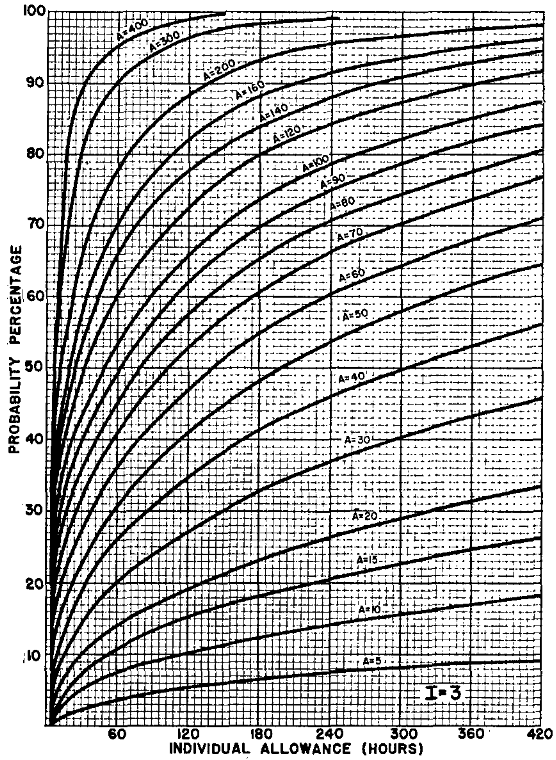



*Figure 3.52 Type II Individual Allowance A Curves (Generated): I Value of 3.*

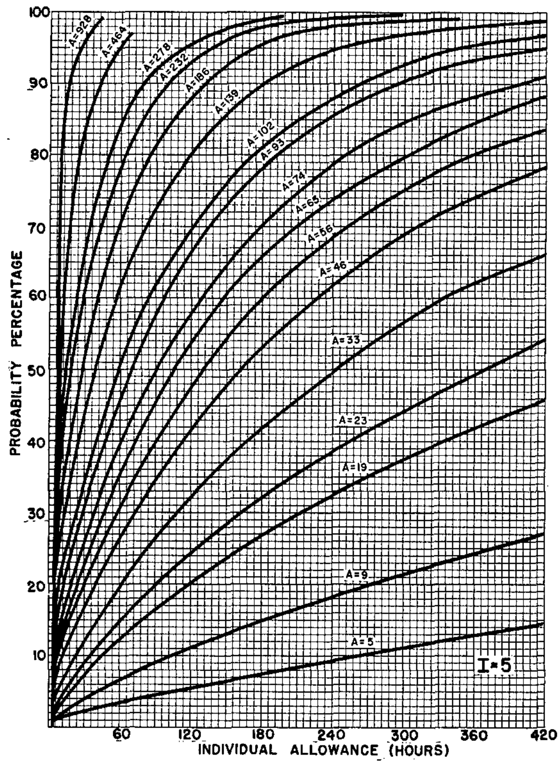



*Figure 3.54 Type II Individual Allowance A Curves (Generated): I Value of 5.*

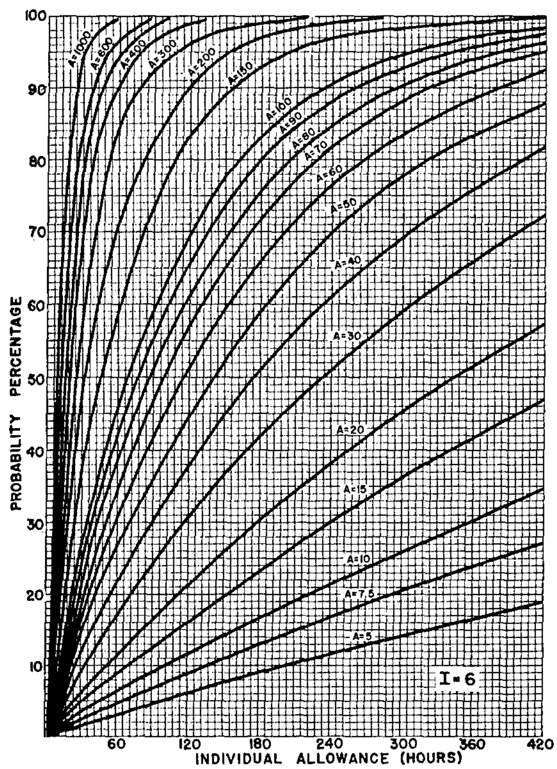



*Figure 3.55 Type II Individual Allowance A Curves (Generated): I Value of 6.*

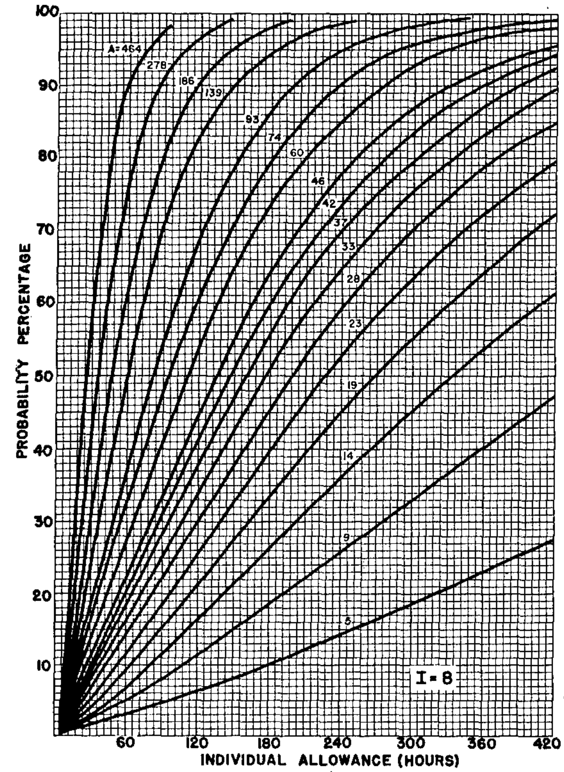



*Figure 3.57 Type II Individual Allowance A Curves (Generated): I Value of 8.*

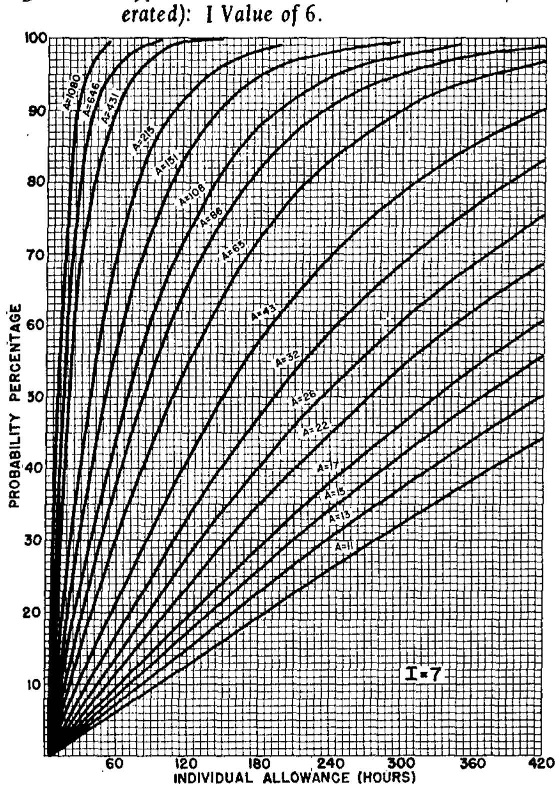



*Figure 3.56 Type II Individual Allowance A Curves (Generated): I Value of 7.*

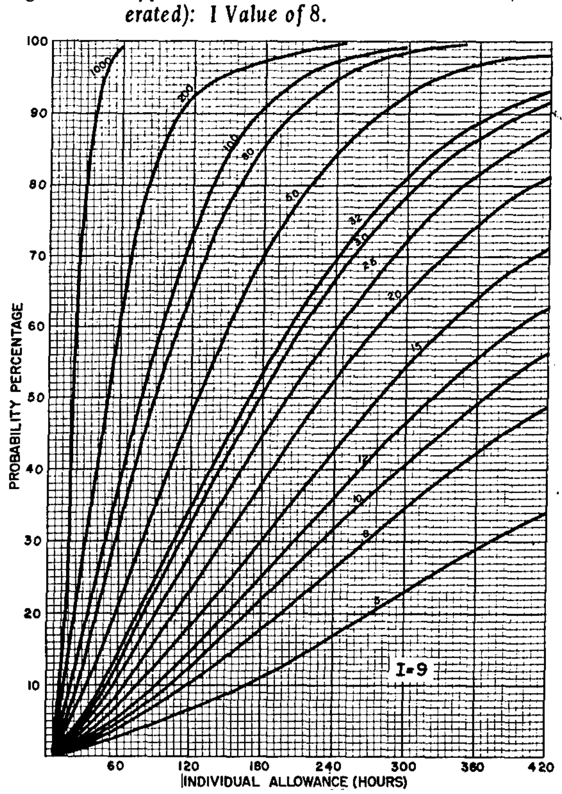



*Figure 3.58 Type II Individual Allowance A Curves (Generated): I Value of 9.*

## 4. CONCLUSIONS

The specific purpose of this report is to provide a system, not previously available, for objectively interpreting a meaningful form of climatology in ocean areas where few observation records exist. Most carrier task force operations take place in such areas, located between widely spaced reporting stations. Therefore, this system is considered valuable when used in planning these operations. It was developed from existing meteorological probability graphs prepared from surface observations that were gathered by selected North Atlantic and North Pacific Ocean station vessels. Some of the graphs were published in previous Navy Weather Research Facility reports. Such graphs provide values of meteorological probabilities useful in planning operations near these ocean vessel stations. For example, by determining probable durations of weather suitable or unsuitable for operations, we can supply enough information to effectively plan the operations. Thus, the meteorological probability system set forth in this publication implements existing information and uses it as a tool for providing planning data in regions of sparse observations between ocean vessel stations.

## REFERENCES

1. U.S. NAVY WEATHER RESEARCH FACILITY, *Meteorological Probabilities for Planning Carrier Task Force Operations in the North Atlantic*, *NWRF 13B–0959–027, Norfolk, Virginia. pp. 1–75.* September 1959.

2. U.S. NAVY WEATHER RESEARCH FACILITY, *Meteorological Probabilities for Planning Carrier Task Force Operations in the North Pacific*, *NWRF 09–0662–061, Norfolk, Virginia. pp. 1–27.* June 1962.

3. CASE, S. D., JR., *Some Applications of Meteorological Probabilities*, *Journal of Applied Meteorology, Lancaster, Pennsylvania, American Meteorological Society, Vol. No. 1, pp. 489–496.* December 1962.

Navy Weather Research Facility (NWRF 09-1165-110)
A METEOROLOGICAL PROBABILITY SYSTEM FOR PLANNING CARRIER OPERATIONS. November 1965. 57 pp., including 90 figures and 4 tables.
UNCLASSIFIED

This report provides a method, not previously available, for objectively interpreting a meaningful form of climatology in ocean areas where few observation records exist.

Estimation of meteorological probabilities and their practical applications are explained with examples. Operational data for estimating two types of meteorological probability values are provided.

Meteorological probability estimates are concluded to be significantly valuable when planning carrier operations in regions located between widely-spaced reporting stations.

1. Meteorology.
2. Probability Graphs.
3. Operational Planning.
4. Climatology.
5. Climatology Interpretation.
6. Silent Areas.
I. Title: A Meteorological Probability System for Planning Carrier Operations.
II. NWRF 09-1165-110
TASK 9

UNCLASSIFIED

Navy Weather Research Facility (NWRF 09-1165-110)
A METEOROLOGICAL PROBABILITY SYSTEM FOR PLANNING CARRIER OPERATIONS. November 1965. 57 pp., including 90 figures and 4 tables.
UNCLASSIFIED

This report provides a method, not previously available, for objectively interpreting a meaningful form of climatology in ocean areas where few observation records exist.

Estimation of meteorological probabilities and their practical applications are explained with examples. Operational data for estimating two types of meteorological probability values are provided.

Meteorological probability estimates are concluded to be significantly valuable when planning carrier operations in regions located between widely-spaced reporting stations.

1. Meteorology.
2. Probability Graphs.
3. Operational Planning.
4. Climatology.
5. Climatology Interpretation.
6. Silent Areas.
I. Title: A Meteorological Probability System for Planning Carrier Operations.
II. NWRF 09-1165-110
TASK 9

UNCLASSIFIED

Navy Weather Research Facility (NWRF 09-1165-110)
A METEOROLOGICAL PROBABILITY SYSTEM FOR PLANNING CARRIER OPERATIONS. November 1965. 57 pp., including 90 figures and 4 tables.
UNCLASSIFIED

This report provides a method, not previously available, for objectively interpreting a meaningful form of climatology in ocean areas where few observation records exist.

Estimation of meteorological probabilities and their practical applications are explained with examples. Operational data for estimating two types of meteorological probability values are provided.

Meteorological probability estimates are concluded to be significantly valuable when planning carrier operations in regions located between widely-spaced reporting stations.

1. Meteorology.
2. Probability Graphs.
3. Operational Planning.
4. Climatology.
5. Climatology Interpretation.
6. Silent Areas.
I. Title: A Meteorological Probability System for Planning Carrier Operations.
II. NWRF 09-1165-110
TASK 9

UNCLASSIFIED

Navy Weather Research Facility (NWRF 09-1165-110)
A METEOROLOGICAL PROBABILITY SYSTEM FOR PLANNING CARRIER OPERATIONS. November 1965. 57 pp., including 90 figures and 4 tables.
UNCLASSIFIED

This report provides a method, not previously available, for objectively interpreting a meaningful form of climatology in ocean areas where few observation records exist.

Estimation of meteorological probabilities and their practical applications are explained with examples. Operational data for estimating two types of meteorological probability values are provided.

Meteorological probability estimates are concluded to be significantly valuable when planning carrier operations in regions located between widely-spaced reporting stations.

1. Meteorology.
2. Probability Graphs.
3. Operational Planning.
4. Climatology.
5. Climatology Interpretation.
6. Silent Areas.
I. Title: A Meteorological Probability System for Planning Carrier Operations.
II. NWRF 09-1165-110
TASK 9

UNCLASSIFIED